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Environmental Monitoring

Dossier: Environmental data for politicians and the public > Scientific data collection is necessary to protect the environment > Forward-thinking monitoring methods > Environmental report for 2015

Monitoring Paves the Way for Action

We smell the wet asphalt and hear the sound of leaves. We taste the essence of spring water, feel the cool breeze and take pleasure in the sight of a marsh gladiolus: When we observe, we behold the object of our attention from a distance and focus all our senses on it.

Yet, science has taught us that many aspects of the environment elude our perception. Sociologist Ulrich Beck notes in his work “Risk Society” that ecological (and other current) threats suffer precisely from invisibility. We need scientific instruments to measure pollutants and determine how climate or biodiversity changes over the years.

The collected data must be made accessible to the public. After all, as informed citizens, we can form our own opinions about the issues at stake. Generally available data can help us identify both looming dangers and successful measures. We can use the data to take thoughtful action and participate in democratic decision-making processes on a daily basis. The Aarhus Convention ratified by Switzerland in the fall of 2013 stipulates that environmental and other types of information should be widely disclosed. In doing so, it creates the basis for strengthening transparency, citizen participation and environmental protection on an international level.

This issue, which is dedicated to environmental monitoring, offers an overview of the diversity of environmental monitoring networks that have been developed over decades. It also presents an assortment of technically sophisticated instruments that deliver extremely high-quality monitoring data, and provides examples of how data are used. We also included stunning photos to rouse your curiosity, illustrate the scientific approach to the environment and reveal the invisible world to you. This should help you sharpen your sense of observation and have fun while you do it.

Bruno Oberle, Director, FOEN

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Cover photo

Head of a meadow brown *(Maniola jurtina)*, a butterfly from the Nymphalidae family. Notice the compound eye and the beginning of the thorax with sections of two legs.

Photo: Ivo Widmer

"Environmental Monitoring" dossier

SCIENCE AND POLITICS IN DIALOGUE

"To be convincing, we need to combine

The words "statistics" and "state" are etymologically related. This reminds us that governance is inconceivable without data. Environment magazine speaks to two experts, a producer and a user of environmental data, who shed light on the interplay between scientific statistics and policy-making.

Interview: Lucienne Rey, Photo: Flurin Bertschinger, Ex-Press

Environment: **Mr. Longet, according to the Swiss Federal Statistical Office, in 1985, 31.1 percent of the land in the commune of Onex was sealed. In 2004, 38.5 percent was sealed. When hearing these figures, what goes through the head of a politician who champions environmental causes?**

René Longet (RL): The figures reflect what is already plain to see — even when you look at aerial photos from the 1930s: Settlement areas had spread out tremendously, and the landscape was fragmented. It is shocking to see this. Still, the visual evidence does not tell the whole truth. After all, not everything that is green is flourishing nature, and not every covered area is a dead zone. Not only private gardens and parks, but also industrial sites returned to nature and military camps can be attractive sites for biodiversity. Agricultural areas, however, are often hostile to many species of life. But to see beyond superficial appearances, we need objective information in the form of scientific data.

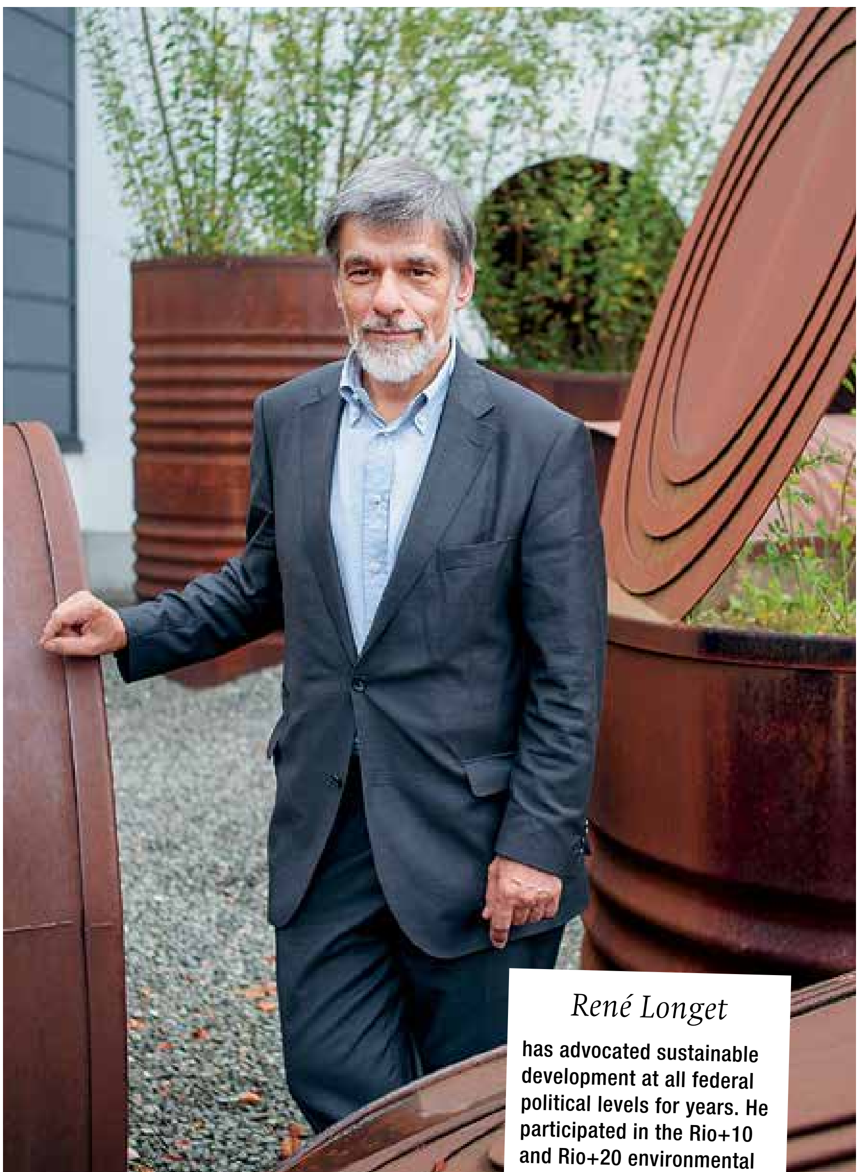
Mr. Kienast – about 60 percent of the city of Geneva is sealed: Does this figure tell us something about the quality of the landscape?

Felix Kienast (FK): Definitely. The sealed area, the settlement area and the urban sprawl index are measured as part of the Landscape Monitoring Switzerland programme, known as LABES. The three indicators show us the heavily built-up areas and the compact settlement structure measures that have helped contain urban sprawl. That is also the actual objective of monitoring: Its main aim is not to lay blame, but rather to identify problematic developments and suggest solutions. Yet, when politicians see that Switzerland's national sealed soil average is only 6 percent, they won't lift a finger.

Felix Kienast

is a titular professor of landscape ecology at ETH Zurich. In addition, he heads the Landscape Dynamics Division of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). In this capacity, he handles many indicators, among other duties, for the Landscape Monitoring Switzerland programme (LABES) led by the FOEN.

knowledge with emotion”



René Longet

has advocated sustainable development at all federal political levels for years. He participated in the Rio+10 and Rio+20 environmental summits, where he represented the point of view of a user of environmental data as a previous mayor of the City of Onex (GE) and a former Swiss National Councillor.

RL: Despite the fact that the national average does not really say that much, especially since almost two-thirds of our country is uninhabited.

FK: Fact is that unsealing efforts are made only when the figures are alarming. If the figure was around 65 percent, policy-makers would contemplate measures such as creating green spaces on roofs, water-permeable flooring, high-density housing or even urban gardening.

The Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) collects data on landscape quality. Do scientists take politicians’ wishes and concerns into consideration when planning these types of analyses?

FK: We try to address topical issues in our monitoring that are being discussed in society and politics. But not only that, we look ahead in many issues, such as by collecting data on perceptions of the landscape. But politicians were behind the initiative to collect data on landscape compatibility with renewable energies as part of our monitoring efforts.

RL: Still, it is important for scientists not to let political agendas pre-determine the issues! We need objective figures that can be used to criticise policies, when necessary. Science is not responsible for filtering data according to the moods of politicians.

FK: We do not filter data, but rather select the issues. If we had followed the political agenda, we may not have measured perceptions of the landscape. In fact, we considered this issue very important, given our society’s focus on recreation. And if the issue ends up on the political agenda at some point, we will already have a time series of relevant data available.

RL: International studies actually confirm that the attractiveness of the landscape can also have an effect on the economy — especially for a tourist destination like Switzerland.

How do the national environmental data benefit cantonal environmental policy? Or in other words, how comparable are federal data and cantonal data?
RL: Data are, for example, critical for the benchmark — and for comparing the monitoring results of organisations or corporations. They are necessary for a coherent policy. In the area of energy, the data also help the cantons see where they stand. Statistics are critical in organising — and evaluating — policy.

> *"Politicians no longer have a pre-emption right to data, and that helps us introduce figures from the scientific data collection process into the political discussion."*
>
> *Felix Kienast, scientist at the WSL*

FK: Yes, the cantons should be able to compare their data with each other. To do so, the Swiss federal government tries to provide a large quantity of high precision data. This makes it possible to draw conclusions about individual cantons.

RL: Unfortunately, this is not possible for every issue. Decentralised figures for CO_2 emissions are very important. But we don't have them.

FK: Indeed, there are not suitable methods of converting national to cantonal figures for all issues; this is often due to the large amount of resources required to collect data. But by measuring perceptions of the landscape, we are trying to obtain specific information about the cantons, despite the shortage of resources.

Data are an important basis for decision-making in evidence-based policy, where policy is developed on firm findings. But evidence can also be corroborated by economic or sociological studies. And data from different areas may at times be used to recommend conflicting decisions. How do politicians get around these conflicts?
RL: The art of good policy-making lies in solving conflicts at the higher levels. It goes without saying that people have to be doing well economically. But in the long term, there is no economy without natural resources. That is also the goal of a sustainable economy. In politics, the prevailing attitude needs to be that protecting nature and developing society are not necessarily conflicting goals.

FK: In science, we are trying to solve this dilemma with the concept of ecosystem services. Science is making major strides along these lines. But what is also helping evidence-based policy is that data have become way more accessible: The public can even consult them with Google Maps and get a sense of the developments. Politicians no longer have an exclusive pre-emption right, and that helps us introduce the figures from the scientific data collection process into the political discussion.

RL: Actually, science is now more important to politics than it once was, and political debates involving data have become a normal part of the process. Data collection methods, which are continuously being developed, are creating optimism; what isn't so positive, however, is that policy tends to lag behind science.

So are political debates on problems now more heavily shaped by scientific data than before?
RL: The climate and ozone debates have at least spilled over from science into politics. Whenever a global perspective is involved, the stimulus comes from science. The problem with these types of issues is that they are not readily experienced in everyday life. This is where dialogue between science, society and politics is important.

FK: That is precisely why virtually all of the larger science projects now make sure that they open dialogue with all interest groups. It seems to me that both sides have become better partners: Politicians have a better understanding of scientific projects and their occasionally conflicting results, and scientists now see themselves more as part of the social system.

Have data collected by the WSL ever been misunderstood or misinterpreted?

FK: To date, there have not really been any incorrect conclusions drawn from our landscape monitoring findings. There have been some unexpected findings, and though we were able to interpret them properly using scientific methods, they were not always easy to understand. For instance, in Ticino, the public's answers in the perception indicators turned out to be similar to those in densely settled agglomerations. At first glance, they did not fit the image that many people and politicians have of the Ticino landscape. But if you know that large parts of this canton are urbanised, this finding is not surprising.

> *"Science is now more important to politics than it once was, and political debates involving data have become a normal part of the process."*
>
> *René Longet, politician*

RL: Politicians need to become better acquainted with scientific methods. But at least there are now legal instruments to make them more aware of the need for data. Environmental compatibility tests, zoning plans for pylons and other such groundwork cause politicians to systematically ask for data.

Mr. Kienast, are you satisfied with the way that your data are perceived and used by politicians and the administration? Or do you sometimes wish that your findings would make more of an impact?

FK: Fortunately, the landscape issue allowed us to put our finger on the pulse of the population: People see the landscape every day on their way to work, or when they relax. That is why we often find that politicians are ready to listen.

RL: Personally, I find the discussion about the landscape somewhat uncomfortable. Because the landscape is constantly changing — and most people perceive this change as a negative development at first. We see this, for example, with the renewable energy production plants that nobody wants to have.

FK: Renewable energy is an interesting example. If we replace not only nuclear energy, but also petroleum and natural gas, society will have to come to terms with energy consumption and the desirability of these infrastructures. This will require a solid plan with exclusion zones and social acceptance. And to attain acceptance, society will first need to attribute a symbolic value to these infrastructures. But we still have a long way to go for that.

RL: Hydropower was highly controversial at first, but views on it have definitely changed over the years. In the 1940s, people were not happy about it. Today, many see it differently.

You bring up the historical aspect: How are new problematic situations incorporated into monitoring without endangering comparability to past data collections?

FK: Lengthy time series are necessary to identify problems early on. For that reason, we develop our monitoring as much as possible on data sets that can be subsequently expanded. Everything that can be reconstructed from the 1:25,000-scale national map is suitable for this, and we work with many similar types of indicators.

Do these long-term statistical series help politicians communicate planned measures?

RL: Yes, because there is a lot of interest in historical developments. We have always struggled with the discrepancy between the data and the personal experience. We can create a personal relationship with historical data by showing that people also discussed their environmental problems in the past. This makes for a good approach and draws attention. History and geography are integrated — and this creates a connection. This is particularly important to me: We can only convince people when we combine emotion with knowledge.

Additional links to the article:
www.bafu.admin.ch/mag2015-1-01

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POLLUTION

Positive Results with a Few Grey Areas

Monitoring programmes once opened our eyes to heavy pollution levels and excessive nutrient inputs in the air, water and soil. Today, long-term monitoring programmes are showing that countermeasures definitely yield results. But there is still much work to be done. *Text: Beatrix Mühlethaler*

In the 1980s, sulphur dioxide levels caused by burning thermal and motor fuels strained the environment and contributed significantly to the formation of acid rain. Today, sulphur dioxide emissions have shrunk to a tenth of their levels in the 80s and are almost not a problem anymore. Air pollution measurements prove it. The positive development in sulphur dioxide is primarily due to the removal of sulphur from heating oil and diesel, which the Swiss federal government ordered after the problem had been identified.

The positive development in sulphur dioxide is primarily due to the removal of sulphur from heating oil and diesel, which the Swiss federal government ordered after the problem had been identified.

Regulations on exhaust emissions from heating, municipal waste incineration and industrial installations, as well as limit values for exhaust emissions from motor vehicles, have lowered the emissions of other pollutants. In fact, nitrogen oxide pollution has declined significantly since 1990. However, nitrogen inputs from the air are still too high (cf. also "Stickstoff — Segen und Problem" in *umwelt* issue 2/2014). This can be largely attributed to ammonia from agriculture. In species-rich dry and wetlands, for example, unwanted fertiliser eliminates species that are unable to compete, and this reduces biodiversity.

The health risks are also enduring because local levels of ozone, particulate matter and carcinogenic pollutants are too high. In sum, Switzerland came closer to the targets of the Ordinance on Air Pollution Control of 1986 but did not fully achieve the "clean air" goal.

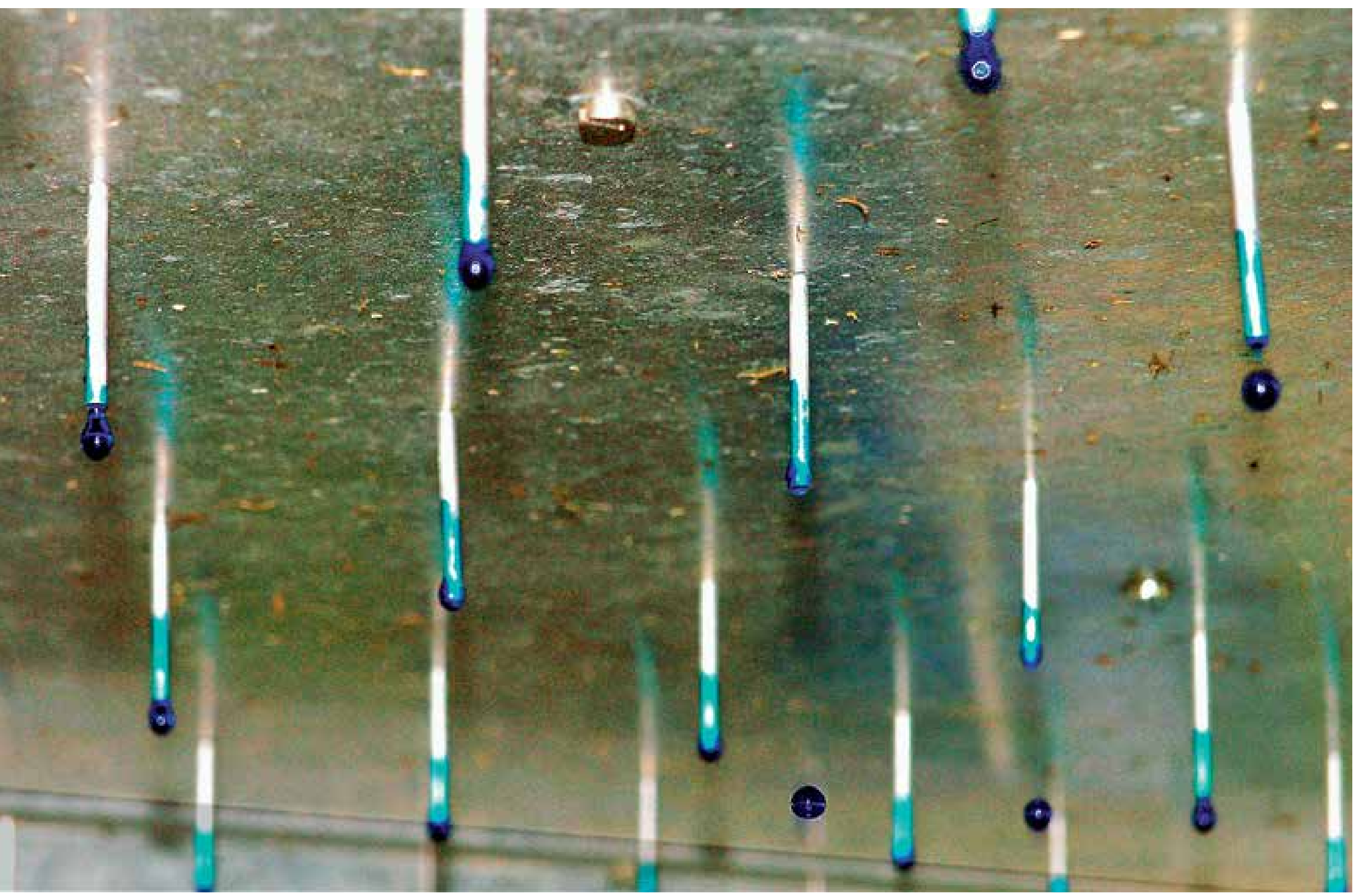
A series of measurements makes it clear

The 16 monitoring stations of Switzerland's National Air Pollution Monitoring Network (NABEL), which the federal government has operated since 1979, monitor long-term changes in air quality. They measure the most important air pollutants. The cantons also monitor air quality because they are responsible for implementing the Ordinance on Air Pollution Control within their territory.

Long-term monitoring programmes have also had considerable success in protecting bodies of water. For instance, the Swiss National River Monitoring and Survey Programme (NADUF) introduced in 1972 shows how much heavy metal and nutrient pollution has decreased. The phosphate load in Basel's section of the Rhine River has dwindled to 20 percent of what it was in the late 1970s, thanks to phosphate precipitation in waste water treatment plants and the ban on phosphate in laundry detergents.

Separately collected measurement data for lakes also show a positive development: While phosphate levels in the 1970s rose to over

Mycorrhizas are fungi that colonise a plant's roots and live in symbiosis with it. They are an indicator of soil fertility. *Dominikia bernensis*, the fungus pictured here, comes from a no-till field in Rubigen (BE) that is farmed using a 6-year crop rotation. It has the name Bern in it because it was isolated for the first time in that canton. *Photo: Fritz Oehl, Agroscope*



Irrigation experiments are used to analyse water flow and the passage of particles and nutrients into the soil. The underground flow paths are marked with a brilliant blue dye. The photo shows the nozzles of an irrigation system. The water hoses above the nozzle plate give an idea of how complicated it is to ensure uniform drop distribution. The artificially irrigated soil is dug up on the side and fitted with drainage tubes, and the extracted soil water is analysed for colour distribution. Project in Saurenhorn, commune of Schüpfen (BE), by Prof. em. Peter Germann, Institute of Geography of the University of Bern. *Photos: Hans Rudolf Wernli*

500 microgrammes per litre in extreme cases, they are now below 20 microgrammes in most lakes. The situation is still problematic in areas where intensive livestock farming occurs. The nitrogen balance — both in the air and water — is unclear: Nitrate levels in watercourses have fallen, but not enough yet. Nevertheless, the limited use of mercury has clearly reduced these levels in watercourses, while lead pollution has decreased thanks to lead-free petrol.

In the meantime, the focus has switched to other environmental threats such as micropollutants from medicines or biocides. New solutions are required for these threats. To find them, Switzerland's federal and cantonal governments introduced the National Surface Water Quality Monitoring Programme (NAWA) in 2011. Along with a higher number of monitoring sites and the additional biological data collected, this programme tackles the problem from a broader perspective.

Soil never forgets

While the pollutants measured in the air or in bodies of water strain the environment as a whole, they are especially problematic for soil. Non-degradable substances that end up in the soil are stored there, where they threaten the quality of resources that are vital to people, animals and plants. The decrease in pollution levels of certain hazardous substances and nutrients can be measured in the air and water, but not necessarily in the soil. "The soil has a long memory; while it generally takes a long time for high pollution levels to be detected in the soil, it takes even longer to get them to drop", explains Fabio Wegmann of the FOEN's Soil Section. That is why the long memory of soil is used to compare how persistent pollutant levels have changed, as this is very informative.

The pollutants measured in the air or in bodies of water strain the environment as a whole, but especially soil.

Studies in the early 1980s were the first to show that hazardous substances from the air are stored in the soil and threaten its fertility. The main culprits were heavy metals such as lead, cadmium, copper and mercury, which have a growth-inhibiting or toxic effect in large concentrations. They enter the soil partly from combustion engines and industrial smokestacks and partly from sewage sludge, various fertilisers and pesticides.

To find out the changes in pollution levels and respond to them, the federal government set up the Swiss Soil Monitoring Network (NABO) in 1985: Samples are taken and studied on a five-year cycle at the one hundred or so sites located in forests, farm fields and parks across Switzerland. Three decades after monitoring began, various trends can be discerned from the reliable findings of the five data collection periods. The findings confirm that environmental measures are slowing soil pollution, but hint at new problems too.

Pollution has also been partially eliminated from the soil

In recent years, cadmium levels have not risen in the top soil, and lead and mercury levels have even declined. In addition, the soil reflects the lower inputs from the air, thanks to more

Complex process: from sample to result

bm. *Acquiring comparable soil data over decades is a complex task because many factors between sample collection and analysis can influence the results. For that reason, there are detailed rules for this entire process, which falls within Agroscope's responsibility. To ensure that samples from all measuring periods are taken in the same area, every one of the 100 sample plots are 10 × 10 metres in size and are located with buried magnets and GPS data. Five mixed samples are taken from every 25 cores in the sample plots, and one is immediately deep frozen. This way, highly volatile pollutants can also be analysed. In the laboratory, foreign material is removed from the soil, which is then dried, ground and strained until it is ready to be measured for pollutants and other properties. Influential factors such as humidity, weather, agricultural crop and anomalies are noted when the sample is taken and are considered when the results are interpreted.*

efficient filtering systems and the ban on leaded petrol. Furthermore, banning the application of sewage sludge has eased the burden on the environment.

However, the concern is that the falling levels in the top soil samples analysed are not due to the disappearance of persistent substances. These substances may simply be stored. After all, they can enter the subsoil or be absorbed by plants and carried off with the harvest. It is also possible for heavy metals to occasionally enter the groundwater or be carried away by erosion.

The primarily positive development has revealed findings on two metals: copper and zinc. Certain concentrations have an inhibiting effect on soil enzymes and also threaten the fertility of the soil. Both elements continue to accumulate, especially in intensively farmed grasslands and certain fields. Also, zinc debris from tyres goes into the air and then makes its way into the soil. But agriculture is clearly responsible for most of the pollution: Copper and zinc ends up in the soil when farmyard manure is intensively applied. They enter the fertiliser cycle as feed additives. Copper and zinc are essential trace elements, which are absolutely necessary for animals. Yet, according to the authors of a report on national soil monitoring from 1985 to 2009 that was published in 2015, their levels in feed could be greatly reduced without adversely affecting animal health.

Cantons determine their own focuses

"Intact soil is a quality that should be protected, like clean air and water", argues Fabio Wegmann in favour of intensive soil monitoring. In addition to the federal government, the cantons also monitor soil because it is their responsibility to detect suspected pollution and start cleaning it up, as needed. Therefore, they focus their attention on various areas, depending on their needs.

The Canton of Fribourg, for example, is particularly interested in key agronomic data due to its vast expanses of farmland. Since 1987, it has regularly tested soil quality at around 250 monitoring sites. After 25 years, the soil protection coordination group gives a positive assessment of the essential aspects of soil fertility: The top soil is stable, and so is the pH value. The latter, however, was only made possible by using acid-reducing lime fertilisers in the Molasse region. Furthermore, the surpluses of soluble phosphorous have decreased, which has reduced phosphorus leaching. But undesirable developments have also been discovered, which require adaptations in farming. Some of these include soil erosion and compaction and excess potassium levels due to high livestock density.

Action is required for nutrient balances

Nutrient balances are also a topical issue for national soil monitoring. Nitrogen and phosphorous levels in grasslands were on the rise until 2000, when they stabilised but remained high. Potassium levels have continued to climb. For that reason, the NABO team wants to increase its analytical activities in this area so that it can identify non-sustainable farming methods and recommend actions. To support these activities, measurements are compared with data on nutrient inputs and outputs on the concerned parcels.

Since all NABO samples are archived by Agroscope, a Swiss federal research institute, other characteristics of the samples can be analysed at any time whenever new issues arise. Accordingly, one of the NABO's main duties is to prepare a well-documented and consistent soil sample archive for future generations.

Additional links to the article:
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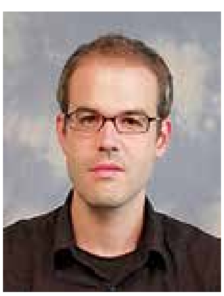
CITIZEN SCIENCE: IT TAKES A COMMUNITY TO CREATE KNOWLEDGE

Keep Your Eyes Peeled!

UrbanGene is asking Geneva residents for some assistance: It wants their help in finding the ponds where toads live. But this study not only focuses on the endangered amphibians. It also investigates stocks of a small butterfly and a variety of herbaceous plant. Through this project, researchers want to learn more about the ecological and evolutionary mechanisms that help promote biodiversity in an area that is subject to heavy settlement development. *Text: Cornélia Mühlberger de Preux*



Nature enthusiasts in the Geneva area are being asked to pay attention: Whenever they come across a pond around Geneva on their way to work or on a walk, they should report it to UrbanGene. And they should definitely do so if they have seen a toad that is protected in Switzerland. These amphibians migrate in early spring to bodies of water, where they lay their eggs and wrap their spawn strings around plants. "The clock is ticking, because the spawning period lasts only about two to three weeks", explains Ivo Widmer, biologist, genetic ecology expert and co-founder of UrbanGene. Then, the animals disappear again in the forests, where they are much more difficult to track.

This large-scale project, which will be carried out under the direction of the Laboratory of Geographic Information Systems (LASIG) at the Swiss Federal Institute of Technology in Lausanne (EPFL) and in cooperation with the "Grand Genève" agglomeration programme, plans to use genetic information to investigate how settlement development affects biodiversity. UrbanGene concentrates on the Canton of Geneva, the Nyon district (VD) as well as several French communities — an area with a total population of around 950,000. The decisive factor in achieving representative results is comprehensive coverage of the habitats of all species under study.

"It is important to know how species migrate and are affected by settlement development."

Ivo Widmer, biologist, UrbanGene

"Settlement development leads to natural habitat fragmentation and encroachment", says Ivo Widmer. "It is important to know how species migrate and are affected by settlement development. This is the only way we can prepare instruments and recommendations that can be used to develop timely concrete solutions for connecting habitats".

Collected on site

There is a very small window of time in which DNA samples can be collected from toads for analysis. That is why it is so important to know where the animals occur. "Protected species may not be collected or caught in Switzerland. But special authorisation may be granted if it serves the purpose of biodiversity conservation", explains Danielle Hofmann of the FOEN's Species and Habitats Section. She thinks it is a good idea to involve the public in the search: "Participatory approaches encourage individuals to observe plants and animals more intensely and develop their own knowledge".

While Ivo Widmer tracks the toads especially in the spring, in the summer he is interested in the broadleaf plantain *(Plantago major)* and the small white *(Pieris rapae)*, a white butterfly whose wings have gold-coloured undersides. UrbanGene focuses on these three species because they move differently: Toads crawl on the ground, broadleaf plantain pollen and seeds are carried by the wind, animals and humans, and small whites flutter through the air. In addition, they are all found throughout the greater Geneva region and are very common in urban areas. Five transects were noted for the study in consideration of local urban development plans and projects — lines with observation points that lead from the densely settled city to loosely built-up rural areas. The starting point of the star-shaped transects is

follow page 16

The toad *(Bufo bufo)* lays its eggs in strings that are wrapped around plants or branches under the surface of the water. *Photo: Ivo Widmer, Urbangene*

Here's looking at you, kid. A characteristic of the toads is their amber-coloured irises with horizontal elliptical pupils. *Photo: Shutterstock*

Rousseau Island in Geneva. From there, they follow along the Rhone River toward La Plaine, in the direction of Annemasse, to Salève in the French Prealps of Savoie, to the airport and toward Versoix. The studied species were located at several hundred points along all of these lines. UrbanGene's hypothesis is: "The denser and more fragmented an urban space is, the lower the species diversity is."

The leaves of the broadleaf plantain are relatively easy to collect. It is much harder to locate the mobile animals. Their presence also depends more on the season and the weather. For instance, in the wet summer months of 2014, it was especially hard to find the small white. "But even in fair weather, it is also quite a challenge to catch this butterfly because it flies fast and high in a zigzagging pattern", explains Ivo Widmer.

Decoding in the laboratory

It takes less time to conduct tests in the laboratory than it does to carry out fieldwork. After extracting the DNA from the samples, researchers can identify differences between individuals using genetic markers and determine how they are related to one another. These genetic analyses should provide clues to how much the species move from one favourable environment to another and are able to adapt to different habitats. Based on these findings, instruments such as indicators, information systems or maps will be developed and recommendations will be made.

UrbanGene began in March 2013 and ends sometime in 2015. The project will be accompanied by GreenTrace, a study on the roles and importance of biodiversity to Geneva residents carried out by researchers from the EPFL and the University of Lausanne, University of Geneva (UNIGE) as well as the University Hospital of Geneva (HUG). In the first phase, the impacts of settlement development on the selected species will be studied. Then, in the second phase, the focus will be placed on how Geneva residents perceive biodiversity in their environment. And finally, health data will be analysed in order to find out how much proximity to flora and fauna affects or harms well-being and quality of life.

After the UrbanGene project wraps up, the butterfly nets and test tubes will not simply be set aside. Instead, the plan is to continue the research but focus on other species and issues such as the influence of artificial light on biodiversity.

Geneva residents are now on board

As for the toads, they are more threatened in urban areas than small whites or broadleaf plantains, especially because humans rapidly change the landscape and expose the toads to great risks when they cross streets. Anyone who discovers a pond and wants to report it can do so through the WebGIs platform at http://urbangene.heig-vd.ch. "It is extremely easy. Just enter the site on a map specially designed for that purpose using GPS coordinates. Interested parties can also provide other data on species they've sighted or answer additional study questions", adds Ivo Widmer. They also have the option of following project phases and development on the UrbanGene Web site and in social media such as Facebook.

Additional links to the article:
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Citizen science on the Internet

Geneva is not the only place where science relies on the observation skills of nature enthusiasts and experts.

www.infospecies.ch is a platform supported by the FOEN that provides access to various species centres. It is intended for connoisseurs who can differentiate, for example, between Knautia godetii *(long-leaved scabious) and* Knautia velutina *(fuzzy-leaved scabious) for reported findings.*

www.opennature.ch allows non-experts to report their observations on the seasons, extreme weather, animals and plants.

www.stadtwildtiere.ch is mainly dedicated to the Zurich region. This site lets you report wild animal sightings and upload photos without an account.

http://www.phaeno.ethz.ch/globe is intended for school-aged children and anyone who is interested in seasonal phenomena such as leaf growth or the flowers of specific plants.

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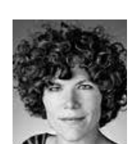

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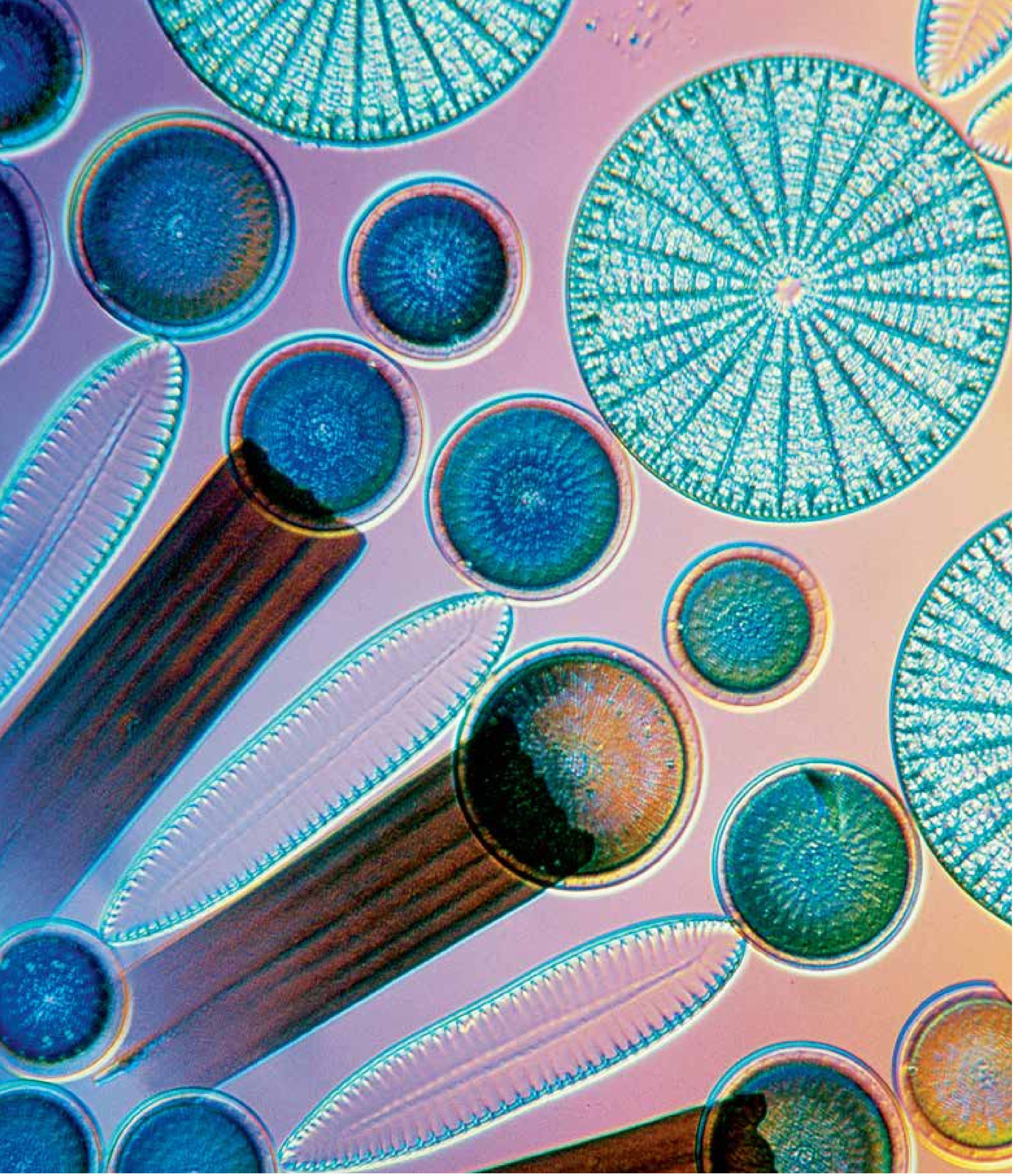
The Danube Delta, the largest estuary after the Volga Delta, is fed from the west by three branches of the Danube River. This photo, which was taken on 5 February 2014 by the Earth Observatory satellite operated by the U.S. National Aeronautics and Space Administration (NASA), shows the northernmost section of the Chilia distributary. The small city of Vylkove can even be spotted just above the centre of the photo. Due to its numerous canals, it is also known as the “Venice of Ukraine”. Quartz sand dunes form bright rolling arcs against the rich brown of the marshland. *Photo: NASA Earth Observatory*



Diatoms can be found in both fresh and salt water. They accumulate on the seafloor or settle on stones or aquatic plants. Several species flourish only in clean water and are therefore an indicator of unpolluted water. Others are typical in rivers and lakes that are polluted by agricultural inputs, especially over-fertilisation. For that reason, diatoms qualify as indicators of the quality of watercourses. *Photo: mauritius images*

INTERNATIONAL INFORMATION SHARING

Environmental Data for a Connected World

GEO and GEOSS, UNEP and EUA, EIONET, UNECE and so forth: This is not some random gibberish, but rather a list of institutions that enable easy access to reliable ecosystem data, which is an essential basis for effectively counteracting environmental problems that transcend borders.

Text: Stefan Hartmann and Lucienne Rey

Is it possible to model development scenarios for a region that spans more than 24 different countries, covers an area of 2.2 million square kilometres and has a population of 160 million? This was the initial question asked by EnviroGRIDS, a project designed to analyse relevant conditions in the catchment area of the Black Sea and uncover sources of surplus nutrients such as nitrates or phosphate that pollute the ecosystem. Its biggest investor was the European Union's Seventh Framework Programme.

The EnviroSPACE group of the University of Geneva coordinated this ambitious initiative on behalf of GRID (Global Resource Information Database). GRID is a network of centres supported by the environmental data base of the United Nations Environment Programme (UNEP). The main objectives of EnviroGRIDS were to develop methods and specialised knowledge and test them in practice so that data could be shared with other institutes and countries and then processed together.

Knowledge is power

"We had very positive experiences working with our partners", maintain Anthony Lehmann, Head of EnviroSPACE laboratory, and Nicolas Ray, Head of the Environment and Geoprocessing Unit of EnviroSPACE laboratory, who were both responsible for coordinating with over 30 partner institutions. "For many, it was their first experience in a European programme, which really injected a huge dose of motivation into the project." Still, collecting the required information did not always go smoothly. Nicolas Ray noticed that collaborators from countries that were previously heavily dependent on Moscow had a hard time working independently and wanted stricter guidelines – although their expert knowledge was outstanding. Anthony Lehmann confirms this: "Partners from countries that were previously a part of the Soviet Union also ran the risk of legal consequences if they delivered their data to us."

> *"The lower the economic level, the lower the quality of the environmental monitoring is too."*
>
> *Anthony Lehmann, EnviroSPACE Lab*

Actually, environmental data are often meaningful from a geostrategic perspective. For instance, there are countries on the upper reaches of rivers that feel entirely justified if their neighbours below them do not know how much water is being diverted for their needs. But geopolitics is not the only obstacle to sharing environmental information. "The lower the economic level, the lower the quality of the environmental monitoring is too", explains Anthony Lehmann. When financial resources are lacking, the collected data may also be sold for money. “This is the worst thing that can happen”, adds the biology and statistics expert.

Geneva – a hotspot for global environmental data

In Geneva, scientific data are not only collected and interpreted, but administrative work is also performed. In fact, the FOEN-funded Secretariat of the Earth Monitoring Group (GEO) is headquartered in the same building as the World Meteorological Organization (WMO). GEO organises symposia on pressing environmental topics such as climate change or natural hazards and supports a range of global initiatives. GEO’s central project is the Global Earth Observation System of Systems (GEOSS) — a platform that compiles the environmental data collected around the world. The information gathered as part of EnviroGRIDS is then incorporated into GEOSS as well.

Another Geneva-based institution that provided extensive support to EnviroGRIDS is the European Organization for Nuclear Research (CERN), which shared expertise in processing the huge quantities of data that were distributed across computers throughout Europe. “It would have taken a year to interpret all our data on one single computer”, says Anthony Lehmann. “Thanks to the computer network, the work was done in three weeks.”

Europe also collects environmental data

All large emerging countries and industrial nations participate in GEOSS — even though participation is voluntary. However, Europe has binding regulations on handling environmental data. Switzerland became a full member of the European Environment Agency (EEA) on 1 April 2006 as part of the Bilateral Negotiations II. In addition to Switzerland, 28 EU member states, as well as Iceland, Liechtenstein, Norway and Turkey, belong to the EEA, which was founded in 1990 and is headquartered in Copenhagen. Furthermore, the EEA cooperates with six countries in the Western Balkans (Albania, Bosnia-Herzegovina, Kosovo, Macedonia, Montenegro and Serbia).

Through the EEA, data on the state of the environment is shared across Europe. The agency works actively with various international organisations for that purpose. The EEA requests data streams on 16 areas of the environment from its members. They are recorded by the EEA’s Environment Information and Observation Network (EIONET). Focuses are clean air controls, protection of the climate, soil and water, biodiversity, waste management, material flows and resource efficiency.

The data harmonisation challenge

Switzerland makes an annual contribution of 2 million Swiss francs to the EEA for its participation. Another million is necessary to provide Swiss data to EIONET. The fairly detailed data are compiled at the FOEN, which transfers them to the EEA. As regards clean air controls, the emissions of more than 10 different air pollutants are measured by the Confederation, the cantons and various cities at 35 different monitoring stations spread across Switzerland.

Through its interaction with the EEA, Switzerland is able to gain an overview of how neighbouring countries collect and work with environmental data. Nicolas Perritaz, the FOEN’s liaison officer with the EEA, points out: “Access to standardised environmental information from all over Europe allows Switzerland to compare the success of its environmental protection measures to those of its European neighbours.”

However, there are some challenges in comparing data, which have to be collected according to generally harmonised criteria. EIONET developed the SEIS concept (Shared Environment Information System), which sets the principles for effective standardised data management, so that environmental data can be transmitted and administered in an efficient and coordinated manner.

Informed citizens thanks to accessible data

Environmental data are not only meaningful to science and administration. In fact, they are also a resource that the public can use to see whether policy-makers are justifying their arguments based on correct figures and whether the measures they introduce are actually yielding the desired effects. As far as international rules are concerned, the Aarhus Convention ratified in 1998 by the United Nations Economic Commission for Europe (UNECE) stipulates that environmental information must be publically accessible.

In Switzerland, the Federal Council ratified amendments to the Environmental Protection Act on 1 June 2014 in connection with its accession to the Aarhus Convention. The convention requires full data transparency, but also sets out provisions to protect the environment, such as the 1998 measures to reduce cadmium, lead and mercury emissions. Particulate matter containing heavy metals, particularly from industry, is carried and deposited around the world by wind flows and precipitation. Cadmium, lead or mercury levels can be calculated exactly based on data from the annual reporting of individual UNECE members and meteorological data. For instance, it is also known that 4 percent of the some 650 kilogrammes of cadmium that enter Switzerland's atmosphere comes from Poland and 24 percent comes from Italy, while the largest portion — 52 percent — comes from Switzerland itself. "What is crucial in the UNECE Convention is that the parties, or member countries, commit to taking the legislated measures to reduce emissions", says Richard Ballaman from the FOEN's Air Pollution Control and Chemicals Division.

Synergies between national and international efforts

International activities are generally aimed at giving an additional boost to ongoing national and international environmental monitoring efforts. For instance, in March 2013, the Swiss Federal Council adopted the Green Economy Action Plan. Europe developed the "Resource-Efficient Europe" flagship initiative as part of its Europe 2020 growth strategy to give centre stage to the term "resource efficiency". At the global level, the Natural Capital Declaration (NCD) was drafted in conjunction with the RIO+20 Earth Summit.

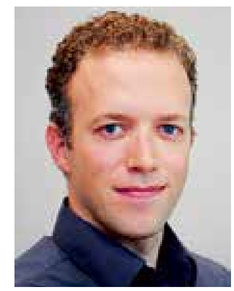
What these fields of action have in common is that they are multi-faceted and bundle data on the state of different natural resources and the extent of the pressure on them. But collecting the required data to monitor developments in these thematic areas is quite complicated. Not to mention the fact that the data must be harmonised internationally for the purposes of comparability. Nevertheless, harmonisation also creates synergies since the green economy is similarly defined by UNEP, the EEA and Switzerland.

From knowledge to action

Even the most comprehensive data streams are hardly beneficial to the environment if they are ignored by policy-makers. Nicolas Ray and Anthony Lehmann have also experienced difficulties in introducing changes to environmental protection efforts despite sound data: "While it was quite complicated just to develop our model, it is even harder to convince decision-makers to use it." Both Geneva-based scientists are now working closely with the International Commission for Protection of the Danube (ICPDR), which was founded in 1994, and the Black Sea Commission, which was founded in January 2009.

"While it was quite complicated just to develop our model, it is even harder to convince decision-makers to use it."

Nicolas Ray, EnviroSPACE Lab



Indeed, this much is true: Given the international material flows and global conditions, solid, scientifically verified data are essential to get the global community to use natural resources sustainably. "Before, humans were directly connected to the nature around them", points out Anthony Lehmann. "Today, we have to create a new connection between humans and their environment using scientific data."

Additional links to the article:
www.bafu.admin.ch/mag2015-1-04

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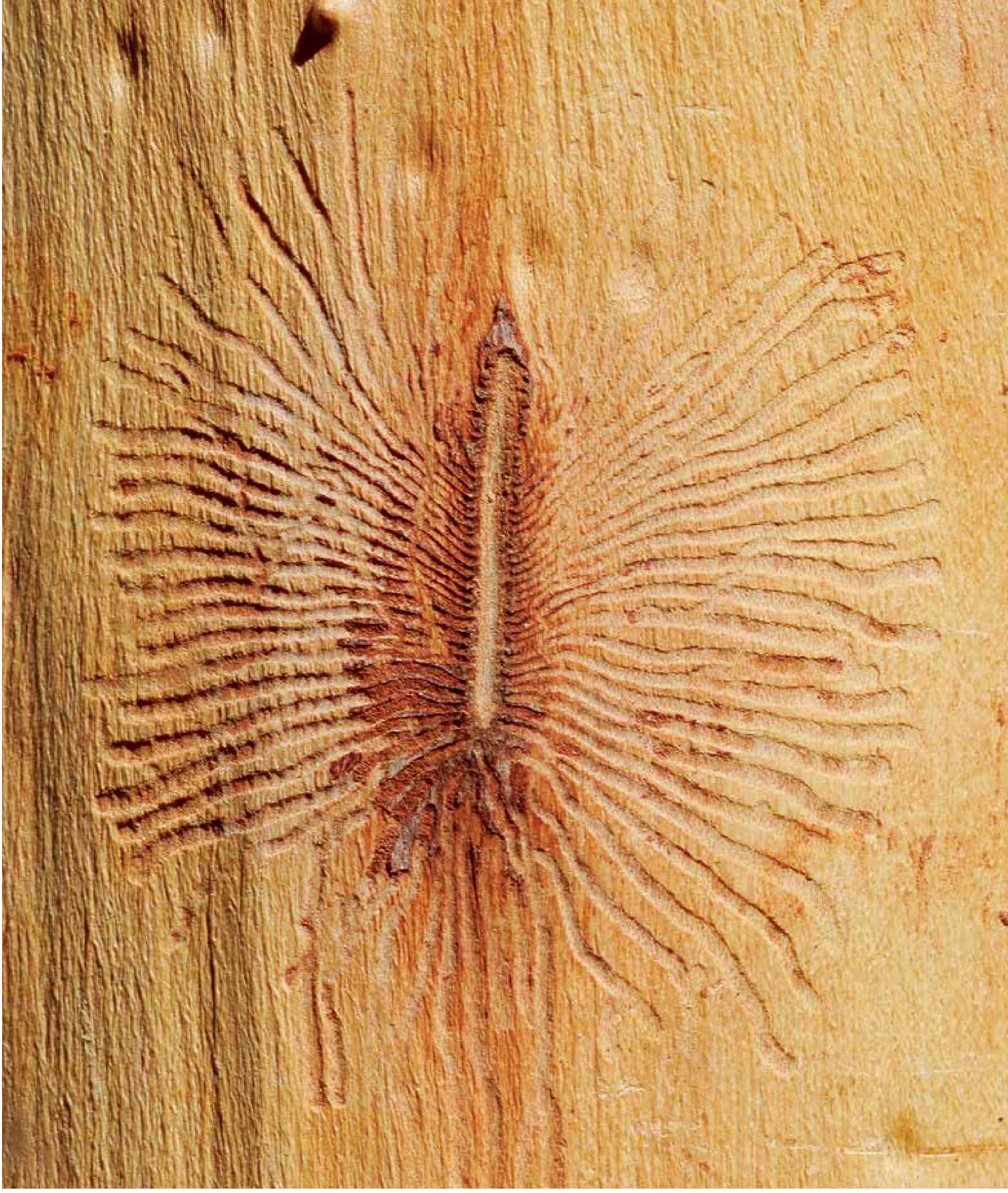
Point dendrometers continuously measure the radius of tree trunks and determine how much they shrink and grow again based on the increasing or decreasing water deficit. TreeNet Switzerland uses these measurements to develop drought and growth indicators for Swiss forest ecosystems. *Photo: R. Zweifel, TreeNet*



An egg gallery with diverging larval galleries of the European elm bark beetle. Elm bark beetles carry *Ophiostoma novo-ulmi*, a fungus, during maturation, i.e. the stage in which they grow into sexually mature animals. In doing so, they contribute to drastic declines in Elm trees, which have suffered from the fungus since the 1920s. *Photo: Beat Wermelinger, WSL*

SOCIAL VALUE ADDED THANKS TO OPEN DATA

Free Flowing Creativity

The FOEN provides the public with increasing quantities of free environmental data – a "creative asset": Resourceful people are taking advantage of the data on smartphone applications. Some of the most popular are water temperatures and river levels. *Text: Nicolas Gattlen*

Christian Studer, founder of the Bureau für digitale Existenz (office for digital existence), can hardly wait. As soon as the Aare River reaches 16 degrees, he will enter it upstream of Marzilibad and let it carry him a couple hundred metres – a tradition and popular sport in Switzerland's capital city. But for now, the Bern native still has to wait awhile; it is March, and the temperature of the Aare has not even reached 8 degrees. Christian Studer regularly follows it on his mobile app ("Aare Schwumm"), which he himself developed as an environmental informatics specialist. In addition to the water temperature, the app also shows the current discharge of the Aare River at the Schönau gauging station, not far from Marzili.

"The idea for the app came to me in 2009 when I was on the Web site of the FOEN's Hydrology Division."

Christian Studer

An incentive for innovation

"The idea for the app came to me in 2009 when I was on the Web site of the FOEN's Hydrology Division", explains Christian Studer. "It was during the era of the first iPhones. When I came across the water data of the Confederation, I thought to myself: 'These could be published in an app.'" So he sent an e-mail request to the FOEN. Its answer "positively surprised" him: The FOEN would provide him with the desired data immediately and for free.

There are several reasons why the Swiss federal government makes data accessible. First, it wants to make administration more transparent and encourage political and scientific discussion. At the same time, it wants to provide businesses with access to raw data so that they can develop innovative business models. In the accompanying text of its Open Government Data Strategy, which it adopted in 2014, the Federal Council estimates the economic potential of administrative data at up to 1.8 billion Swiss francs.

Water data, a rich tradition

The FOEN's Hydrology Division has a large treasure trove of data. Since 1863, the Confederation has systematically measured the water levels of Switzerland's bodies of water. Some data streams date back to the early 19th century, when pioneers collected the water levels for Rhine River boat traffic and the first river training structures were built to protect against flooding. Interest in water data grew as hydropower was increasingly exploited: Electric power plants wanted reliable information about river levels so that they would be able to effectively build and run their plants.

After the first national calibration facility for measuring flow velocity began its operations in 1896 in Ittigen (BE), the Confederation continued to expand its monitoring network. Today, the FOEN's Hydrology Division operates approximately 260 gauging stations for surface water. In addition to lake water level measurements, river discharge is measured at 200 sites, and river water temperatures are taken at 70 sites. 90 percent of the stations have automated remote data retrieval facilities. Depending on the station, the data arrive anywhere from every 10 minutes to every hour at the FOEN's centre, where they are distributed to various clients and Web portals. A machine-readable XML file is available to interested parties on the Web site hydrodaten.admin.ch.

Openness is an obligation

The FOEN has published water data online for around 15 years. Even more data may be published in the future. With its accession to the Aarhus Convention, which governs access to information, among other items, Switzerland has committed to disclose as much environmental data as possible. Another aim is to increase data sharing between environmental authorities around the world. For instance, data on water quality is already being shared right now. The FOEN receives some of these data from cantonal offices and forwards them along with its own data to the European Environment Agency (EEA). The figures are incorporated in the various EU reports and interactive maps of the EEA. One of these even shows the bathing water quality of 22,000 European rivers, beaches and lakes.

The FOEN also publishes a portion of its hydrological data in the form of thematic maps, such as in the "Hydrogeological Atlas of Switzerland", on its geographic portal (map.bafu.admin.ch) or on the geoportal of the Federal Office of Topography (Swisstopo) (geo.admin.ch). The Confederation is increasingly using the "Storymaps" portal to develop narratives on specific themes (c.f. the article entitled "Den Gletscherschwund online verfolgen" in *umwelt* issue 2/2014, pages 46 – 47). One highly viewed map uses water temperature data to determine "the warmest river in Switzerland" in real time. The ranking is updated every hour.

Customised data packets

Different groups are interested in the FOEN's water data. Data policy is set according to needs: "Depending on needs, we make data available in various stages of processing", says Edith Oosenbrug of the FOEN's Hydrologic Information Section. Emergency workers such as firemen and civil protection officers, as well as shipping companies, water sports enthusiasts and fishermen, want to be informed quickly. They can retrieve the updated data on the FOEN's Web site, by text message or using the Joint Information Platform for Natural Hazards (GIN). "These raw data have not been evaluated and mistakes can happen", explains Edith Oosenbrug. "It is possible for lightning to interrupt the power supply of a data logger or for a sand-covered sensor to provide an incorrect reading. That is why we check whether the data are plausible, complete and correct".

It takes several months for the data from the previous year to be cleaned and labelled "definitive" in the data base. The FOEN compiles the data from this data base into "individual data packets" for clients in such areas as hydraulic engineering, planning, hydropower utilisation, water protection and research. For instance, long-term data series and extreme water flow data could be delivered to an engineering firm that is planning to build protective structures along a river in order to prevent flooding. There is a charge for the evaluated data, and their price is determined by the scale, research and amount of processing involved.

FOEN data for countless apps

The FOEN's hydrological data have also become a "creative asset" to private software developers. The river temperatures are especially popular. In addition to Christian Studer's "Aare Schwumm" app, there are dozens of other tools on the market for swimmers, such as "WasserWetter" (Windows), "eiSwim" (Android) or "mAare" (iPhone). Since 2013, apps for kayakers are available based on the FOEN's XML and other files. For example, "RiverApp" (iPhone / Android) provides updated water levels for around 3,000 rivers in Switzerland

and other Alpine countries, plus the USA, and can be consulted using mobile technology. A chart shows changes in water levels in the last 24 hours or 7 days. A "river traffic light" tells you how navigable certain sections of rivers are at a glance. The traffic light colours are red for high water, yellow for medium water, green for low water and grey for not enough water.

The app was developed by Florian Bessière, a 27-year-old computer scientist from Munich. Bessière is a kayaking enthusiast and a frequent user of water and weather data: "They are extremely important in our sport." He used to check river water levels on his PC before he went on kayaking trips. Now, using "RiverApp", he can check this information on his smartphone in real time. "The app has been well received in the kayaking community", says Florian Bessière, as it has already been downloaded 10,000 times.

The app's developer says its success is due to the "quality of the data" and the "free access". However, Bessière points out that it is not necessarily free everywhere. Baden-Württemberg in Germany, for example, did not make river water levels generally accessible to the public, and several regions were charging way too much for their data. South Tyrol charges around 200 euros per level. "We cannot afford these prices", says Bessière, whose main intention is not to earn money, but to help others. He talks about the "social value added".

"The app has been well received in the kayaking community."

Florian Bessière

Corrections by the community

The "RiverApp" is also an example of how the public can help produce more precise environmental data since interested parties can report mistakes in the information provided and contribute additional information. The kayaking community can also report river navigability on the "RiverApp" and read comments from other users. For instance, other kayakers might report a "tree at the last bend before arrival" or changes in the river after flooding, such as a hard-to-navigate section that has become easier to handle or a siphon appearing in a fairly safe section.

Florian Bessière wants to develop his app further. He is working on an alarm system that automatically informs kayakers of high water. But this raises liability issues: Is the app developer also liable for accidents when the warning system fails? Could he even be taken to court? "No", says Florian Bessière and points to the source data on his app.

Clarifications upon request

So are the environmental offices that collect the data and make it available to the public liable? "We are in no way liable for our data", explains FOEN expert Edith Oosenbrug. However, the data have been used, among other things, as a benchmark for diligence when potential liability cases were evaluated. Edith Oosenbrug remembers that once an insurer contacted the FOEN after a boating accident to find out whether the organiser should have expected a high water level based on the information provided by the FOEN.

But there is still one problem: The publicly accessible data that is released can also be misunderstood or misinterpreted. In other words, too much creativity can occasionally cause damage. What is the FOEN doing to mitigate this risk? "Our resources are limited", points out Edith Oosenbrug. "We gladly explain to interested parties what the data apply to in emails or over the phone and clarify the collection methods to them. But ultimately, these data are free, so anyone can use them however they want."

Additional links to the article:
www.bafu.admin.ch/mag2015-1-05
www.hydrodaten.admin.ch

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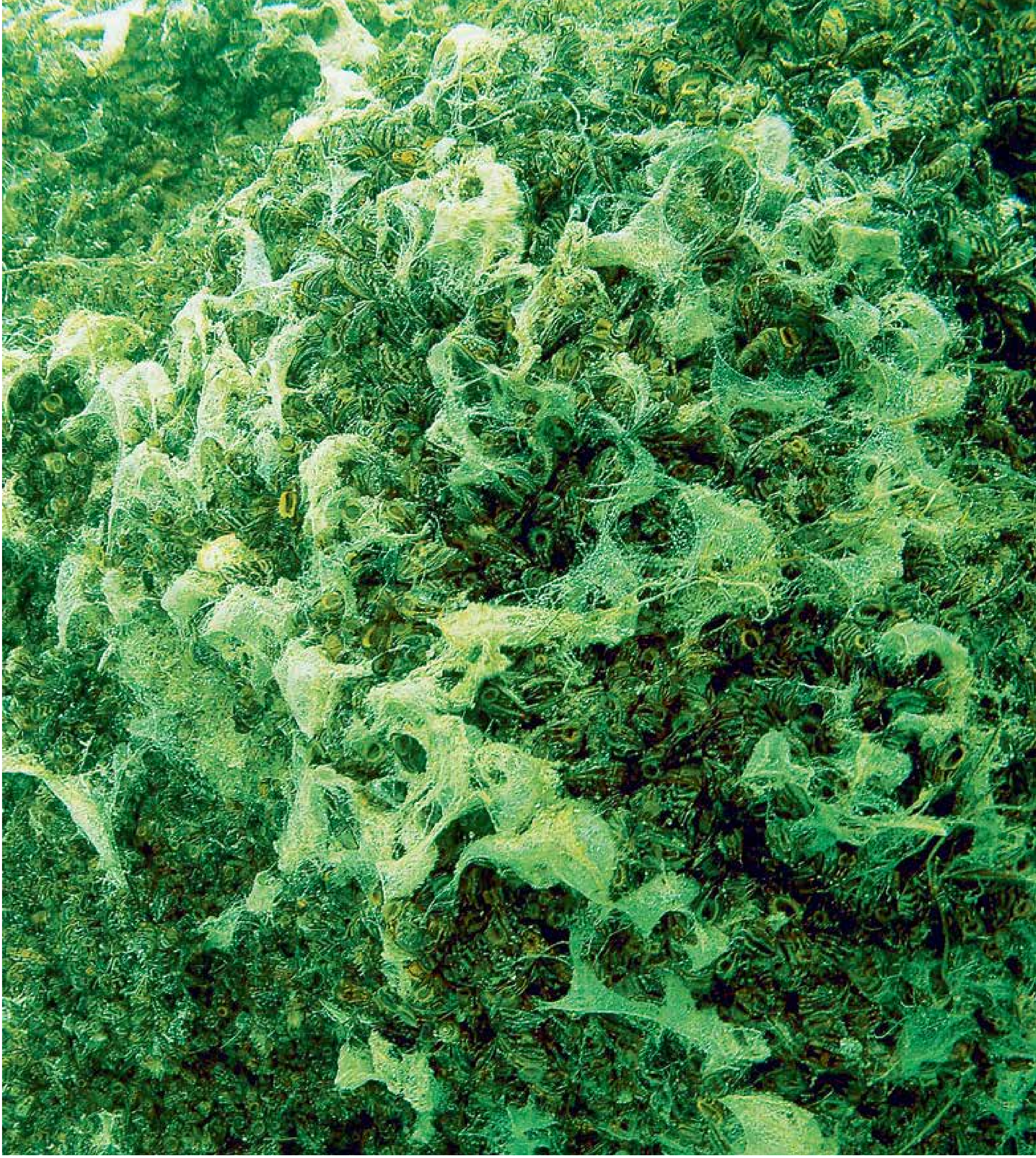

On warm summer evenings, they swarm the rivers. Caddisflies *(Trichoptera)* are water insects with slender antennas that are in most cases longer than their bodies. Their German name is derived from the tubes where their larvae grow. The presence of caddisflies is usually an indicator of good to very good water quality. The catch nets of the *Neureclipsis bimaculata* species can be seen in this photo from the Rhine River. Caddisflies live in large, slow flowing bodies of water, especially near to lake runoffs. Their nets catch zooplankton floating in the current. The larvae sit at the end of the nets, where they collect and eat the particles. *Photo: Patrick Steinmann, AWEL*

On the trail of glacier meltwater: In the summer of 2011, a team of researchers used tracer experiments to investigate runoff from the Plaine Morte glacier on the border between the cantons of Bern and Valais. Most water appeared to run off on the Bern side, and also much more rapidly than previously thought. Project manager: Prof. Rolf Weingartner, Institute of Geography of the University of Bern. *Photo: Hans Rudolf Wernli*

PROBATIVE VALUE THANKS TO THE DIVERSITY OF SOURCES

Undeniable Evidence of Climate Change

Global temperatures should rise two degrees at most. Science and administration are working toward that goal with great urgency. A wide range of diligently interpreted climate and environmental data provide the foundation for their work. *Text: Elsbeth Flüeler*

Seven folders in rainbow colours that go from blue to green and yellow to red sit next to Regine Röthlisberger's desk. The Deputy Head of the Climate Reporting and Adaptation Section says: "This is the 'cookbook' we use to measure Switzerland's greenhouse gas inventory." The result is 80 pages full of figures every year. Plus, there is a 500-page handbook with comments on the figures. The first of three parts of the IPCC report has 1,500 pages and weighs 4.2 kilograms. The fifth edition of the scientific work of the Intergovernmental Panel on Climate Change (IPCC) was published in 2013 and conveys the physics principles of climate change.

Certain industrial nations agreed on binding reduction targets for greenhouse gases under the Kyoto Protocol in 1997. Since then, the Parties to the Protocol have been working to develop multifaceted and precise data that represent their greenhouse gas emissions so that they can introduce specific national reduction measures. As for scientists, they are doing everything they can to issue clear statements on climate change to policy-makers. The last IPCC report included scientific articles about climate issues from a total of 254 authors. Stefan Brönnimann, who leads the Climatology Group at the Institute of Geography of the University of Bern, was one of them. He co-wrote with 14 other authors the report's chapter on observed atmospheric change.

Certain uncertainties

It is more than certain that the global mean temperature has risen. But what does "certain" mean, the authors asked. And how much uncertainty is there in this scientific claim? According to the authors, a finding is really only certain if different types of proof lead to the same conclusion independently from one another. Or in the language of the IPCC report: If there are "multiple independent lines of evidence".

Researchers uncovered the first lines of evidence for the changing world mean temperature in the temperature readings taken at the some 30,000 meteorological stations around the world. "In Switzerland", says Stefan Brönnimann,"we were able to rely on a 150-year tradition of the Swiss Meteorological Institute (SMA) weather stations." However, while the stations were located at the edges of cities when the measurements began, they gradually ended up in the middle of cities or were relocated to airports; the measurement equipment was replaced by new models — and not only in Switzerland, but everywhere where climate data are collected using state-of-the-art research methods. In the past, critics have complained that these changes influenced temperature trend information and created uncertainty.

"In Switzerland, we were able to rely on a 150-year tradition of the Swiss Meteorological Institute weather stations."

Stefan Brönnimann, University of Bern

So Stefan Brönnimann and his colleagues at the climate centres analysed the raw data in view of these changes and made corrections. "Every correction harbours more uncertainties", says the climate expert. However, scientists have been working intensively in recent years on the uncertainties involved in the series of measurements. And it turns out that although the corrections were made independently by scientists, the series of measurements proved to be virtually identical for the most part. “The uncertainties can now be better defined, although it may sometimes seem as if general uncertainty has grown.”

Measurements from various independent systems

In addition to ground temperatures, surface water temperatures in oceans provide a second line of evidence according to an independent monitoring system. The series of measurements on surface water temperatures go way back and raise specific uncertainties. In fact, temperatures used to be mainly measured by ships, with boilers until the 1940s and then engine cooling water.

A third line of evidence came from measuring air temperature – also by ships – and a fourth line of evidence came from determining the temperature of the free atmosphere, measured first with weather balloons and later with satellites. But scientists were still on the lookout for other evidence of warming. They analysed glacier volumes, the spread of artic ice, the sea level, the thickness of the snow cover in winter, the general humidity in the air and the heat stored by the ocean.

The result was 11 measurement categories with a total of 44 processed, interpolated and homogenised data sets that all delivered robust scientific evidence of the change in the Earth’s temperature and dispelled specific uncertainties. “The finding”, says Stefan Brönnimann, “is a good example of how multiple independent lines of evidence can lead to a politically relevant scientific claim.” Despite the uncertainties, the finding was the same in all 11 measurement categories: The climate system is clearly warming.

Greenhouse gases: awareness and its political consequences

The IPCC will use this finding to guide policy-makers as they develop subsequent policy instruments to the Kyoto Protocol. Switzerland will return once again to the negotiating table and decide on climate protection targets. Parliament is now discussing the ratification of the second commitment period under the Kyoto Protocol and the commitment to reduce greenhouse gases by 20 percent from their 1990 levels. The measures used to achieve this and their effectiveness will be reviewed on the basis of the groundwork provided by Regine Röthlisberger.

Regine Röthlisberger also has guidelines for the greenhouse gas inventory. They concern the data that are collected and how they should be prepared, interpreted and calibrated. This is precisely what she has in the 7 folders mentioned earlier. To describe the greenhouse gas emissions from fossil fuels, Regine Röthlisberger and her colleagues compiled data from the areas of households, services and commerce, industry and transport. The energy statistics of the Swiss Federal Office of Energy serve as the basis for this work. In addition, they use figures to show the quantities of greenhouse gases that are generated by the use of substitute materials for chlorofluorocarbons (CFCs) or by agriculture. In the latter case, this involves data on the number of livestock animals and their specific feed. When asked how many data sets are included in the greenhouse gas inventory, Regine Röthlisberger stretches her hands far apart and estimates about 1,000, and growing: “Knowledge and experience with methods of estimating greenhouse gas emissions are constantly growing”, says the expert.

Solid groundwork for political decisions

Science and administration both want precise data on climate and its development. But how well do they work together? Regine Röthlisberger says: “When we set long-term goals as an administrative body or initiate climate change adaptation measures, we are guided by scientific principles.” In her daily work, however, she only occasionally works with scientists. Likewise, Stefan Brönnimann of the University of Bern acknowledges that there are only a few points of contact. Nevertheless, both parties are working independently toward the same goal and support each other in this effort with precise data from thousands of different sources. They do so to guide policy-making and provide support.

Additional links to the article:
www.bafu.admin.ch/mag2015-1-06

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Environmental Monitoring Networks

Swiss environmental monitoring networks record the state of all natural resources. Divided into themes, this overview shows the start date of each monitoring system, its goal and the organisation that collects the data. The start dates of monitoring, the number of monitoring sites, where possible, the data collection rate and the competent institutions are shown in parentheses.

Hydro

- **Hydrological data** show the state of lake water and river discharge (1963; 260 basic gauging stations; Hydrology Division, FOEN).
- The **Swiss National River Monitoring and Survey Programme (NADUF)** monitors developments in water content in selected Swiss rivers (1972; Swiss Federal Institute of Aquatic Science and Technology, Eawag).
- The **Swiss National Groundwater Quality Monitoring Network (NAQUA)** monitors the state and development of groundwater resources (1997; 500 monitoring sites; cantons and Confederation).
- The **Swiss National Surface Water Quality Monitoring Programme (NAWA)** monitors changes in water levels and damages to the structure of bodies of water (2011; cantons and Confederation).

Forest/natural hazards

- **Swiss forestry statistics** collect data from forestry operations and private forest owners, timber use and planting (1887, online 1975; annually; Swiss Federal Statistical Office, BfS).
- The **Swiss National Forestry Inventory (NFI)** collects basic data on the changes and state of forests (1983; 10-year cycles; Swiss Research Institute for Forests, Snow and Landscapes, WSL).
- The **Sanasilva Inventory** surveys crown condition as an indicator of the health of trees (1985; annual; WSL).
- The **Swiss Long-term Forest Ecosystem Research Programme** monitors external influences and their effects on forests (1994; 19 research plots; WSL).
- **TreeNet** researches forest reactions to climate change (2009; 6 sites; continuously; WSL, ETH Zurich, Institute for Applied Plant Biology, IAP).
- **StorMe**, a natural event register, documents past natural events and provides information about areas at potential risk (1996; cantons).

Biodiversity/landscape

- **Swiss fisheries statistics** provide information about the changes and state of fisheries (1931; annually; cantons).
- **Swiss hunting statistics** provide information about the changes and state of hunting (1933; annually; cantons).
- The **Wild Bird Monitoring Programme** monitors changes in threatened species of wild birds (1950; Swiss Ornithological Institute).
- The **Red Lists of Threatened Species** list the most vulnerable species that require action (1977; various sources).
- The purpose of **Biodiversity Monitoring (BDM)** is to monitor biological diversity in Switzerland (2001; depending on the indicator, anywhere from one hundred to 1,600 sampling areas; coordinated by the FOEN).
- The **Landscape Monitoring Switzerland programme (LABES)** documents the changes and state of Switzerland's landscapes (2008; 34 indicators; FOEN/WSL).

Air/noise

- The **Swiss National Air Pollution Monitoring Network (NABEL)** measures air pollution (1968; 16 monitoring sites; Swiss Federal Laboratories for Materials Testing and Research, Empa).
- The **Swiss National Emission Information System (EMIS)** collects data on emissions from various sources of air pollutants and greenhouse gases (ca. 1985; publication twice annually; Confederation).
- The **Accompanying Environmental Measures Monitoring Programme** shows the environmental pollution caused by the transport of goods along the north-south axis (2003; 6 checkpoints; Confederation and cantons).
- **SonBASE – GIS-Noise** Database of Switzerland provides detailed information about the noise pollution caused by various carriers (2009; Confederation).

Soil

- The **Swiss Soil Monitoring Network (NABO)** measures soil pollution (1984; annually; Agroscope).

Substances/waste

- **Swiss waste statistics** provide data on changes in waste accumulation (1992; annually; various organisations and the Confederation).
- The **Swiss Pollutant Release and Transfer Register (SwissPRTR)** provides information on pollutants and wastes from facilities and diffuse sources (2007; annually; facilities).
- **ECOGEN**, a public register, provides information on research with genetically modified or pathogenic alien organisms subject to contained use (2009; continuously; universities).

Climate

- The **Swiss Greenhouse Gas Inventory** measures all relevant climate gases and related carbon according to UN guidelines (1990; annually; Confederation).
- **Swiss CO_2 statistics** are calculated from the energy statistics and provide information on air pollution (1990; annually; Confederation).

Additional links to the article:
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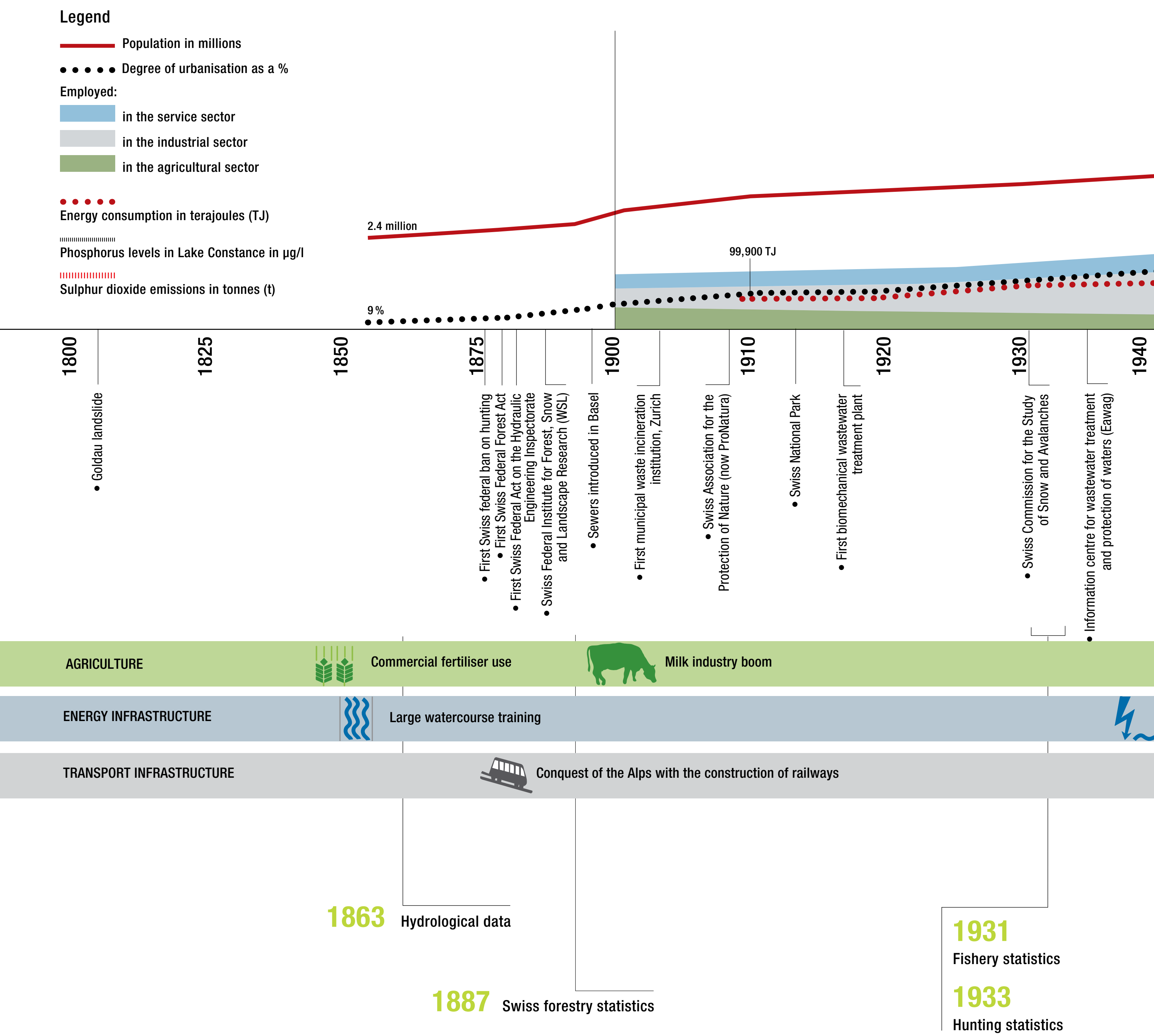
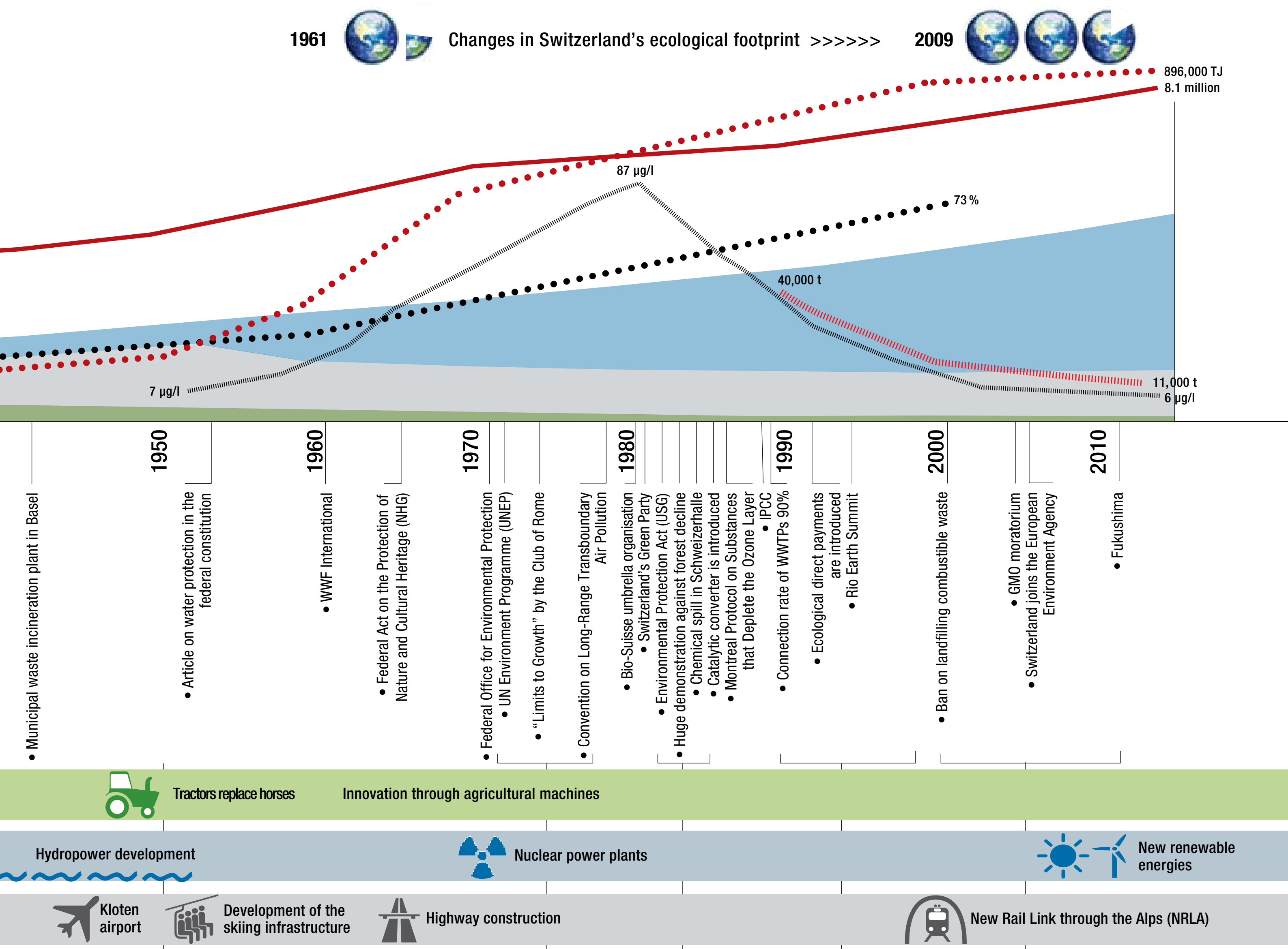


Development of the Monitoring Networks

The Swiss federal government began collecting data on water levels and forests in the early 19th century due to the numerous landslides and floods caused by mountain forest clearing.

After World War II, the consequences of the growing demand for energy, urban sprawl, motorisation and more intensive farming were increasingly felt. Switzerland's federal government has also been measuring pollution levels since the 1970s.

The chart puts the development of the monitoring programme in a historical context. The time axis shows important environmental events and Swiss environmental policy milestones.



1950
Wild Bird Monitoring Programme

1972
Swiss National River Monitoring and Survey Programme (NADUF)

1977
Red Lists of Threatened Species

1978
Swiss National Air Pollution Monitoring Network (NABEL)

1983
Swiss National Forestry Inventory (NFI)

1984
Swiss Soil Monitoring Network (NABO)

1985
Sanasilva Inventory

1985
Swiss National Emission Information System (EMIS)

1990
Greenhouse Gas Inventory

1990
CO_2 statistics

1992
Waste statistics

1994
Long-Term Forest Ecosystem Research

1996
StorMe Nature Event Register

1997
Swiss National Groundwater Quality Monitoring Network (NAQUA)

2001
Biodiversity Monitoring

2003
Accompanying Environmental Measure Monitoring

2007
Swiss Pollutant Release and Transfer Register (SwissPRTR)

2008
Landscape Monitoring Switzerland programme (LABES)

2009
ECOGEN public register

2009
SonBASE – GIS noise data base

2011
Swiss National Surface Water Quality Monitoring Programme (Nawa)

Sources:
Swiss Federal Statistical Office (BFS), Swiss Federal Office of Energy (BFE), Global Footprint Network

NEW TECHNOLOGIES FOR COMPLEX ISSUES

Environmental Monitoring is Flying High

In recent years, the technological possibilities of environmental monitoring have increased exponentially. Nevertheless, human instinct and judgment are still required because not everything can be left to technology. Cost is also a prohibitive factor in how much it can be used. *Text: Mirella Wepf*

Environmental monitoring was originally a down-to-earth science: Soil and water samples were taken, animal and plant species were catalogued, water levels were measured and national maps were developed. But then research took off — in the best sense of the term. In 1858, Gaspard-Félix Tournachon (pseudonym: Nadar) succeeded in taking the first aerial photos of the world from a balloon. He was followed by other pioneers who took aerial photos from airplanes, kites, small rockets and even messenger pigeons, like Hessian apothecary Julius Neubronner in the years after 1910. Another high point was achieved with remote sensing in 1959, when Explorer 6, a U.S. satellite, photographed the Earth from space. But the Earth would not be systematically observed by satellite until 1972, when the Landsat program of the U.S. National Air and Space Agency (NASA) began.

"Depending on the waves emitted by the satellite, it receives different signals from plants."

Irena Hajnsek, ETH Zurich

Remote sensing has continued to create new possibilities for environmental monitoring, and there is no end in sight for its development. Terrestrial measurement methods have not been frozen in time either.

A global and forward-looking view

"Looking ahead to the future, I see two central problems", says Markus Wüest, Head of the Environmental Monitoring Section at the FOEN. The first problem: Switzerland is increasingly shifting its environment pollution abroad due to its imports. In 1996, this percentage was 56 percent, and in 2011, 73 percent. "This is forcing us to take both a global view and responsibility", explains Markus Wüest.

The second problem involves a technically tricky issue: "How do we succeed in recognizing the risks of environmental pollution early on?" As we all know, ecological systems do not develop linearly with pollution. "A fish stock can resist overfishing for a long time and then suddenly collapse." Climate change also conceals similar risks. For Markus Wüest, the following is clear: "This challenge cannot be met with monitoring technology alone. But it can help minimise costly damage and lay the foundations for policy-making."

One example of how environmental monitoring and policy could soon collude is monitoring forests with satellites using electromagnetic waves. "Depending on the waves emitted by a satellite, it receives different signals from plants", explains Irena Hajnsek, Professor of the Chair of Earth

Observation at ETH Zurich. "Long waves even penetrate the forest down to the soil and measure its inner structure very precisely." The CO_2 stored in the biomass could be calculated in this way, which would make it technically easier to implement the UN's "Reducing Emissions from Deforestation and Forest Degradation" (REDD+) programme. REDD+ uses financial incentives to promote the protection of forests as carbon sinks.

New satellite programmes in Europe

In recent decades, following the example of the U.S., Europe has made great strides in space research and developed itself into a player in this area. In fact, the European Union's Copernicus Earth Observation Programme (formerly Global Monitoring for Environment and Security, GMES) launched the first satellite of its Sentinel project in April 2014. Tom Klingl, geoinformation systems expert at the FOEN, explains its advantages: "The EU used to support individual projects; a long-term programme has now been created from the Sentinel satellites." It provides data in quick succession and covers a wide range of electromagnetic waves. "The information provided is based on different environmental parameters, such as various types of vegetation and soil fertility, but also aerosols in the air."

These parameters are important in tracking the effects of ecological change. "It would be interesting for the FOEN if in the future, we could better distinguish the types of crops in agricultural areas", explains Tom Klingl. Why? Farmland and grassland have different effects on nutrient inputs in bodies of water. As a result, it would be possible to develop better models with more up-to-date information on these crops.

Although Switzerland is not a member of Copernicus, many Swiss universities were involved in research projects in its previous programme. And the European Environment Agency (EEA), of which Switzerland is a member, has commissioned all of Europe to be covered by the programme's continuous monitoring. According to Tom Klingl, several data sets being produced right now would interest the FOEN. "Some of them pertain to the forest layer and information about the thickness of tree crowns, the imperviousness layer, which provides an overview of soil sealing, and the urban atlas." The urban atlas provides insightful information about closeness to nature and quality of life in cities.

From large maps to plastic models

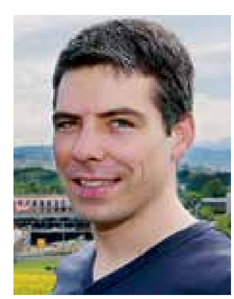
Copernicus is not the only futuristic project. That is also how Irena Hajnsek of ETH Zurich describes Germany's TandEM-X satellite mission launched in 2010. "Two twin satellites are creating a three-dimensional image of the world." Before that, there was no standard model for global elevation measurement. But this type of satellite is urgently needed as the basis for various earth science applications.

"3D images in themselves are nothing new", explains Tom Klingl. "But using airplanes and satellites supplies us with more current data on much larger and more inaccessible sites" (cf. also the article entitled "Massenbewegungen: Radarwellen erkennen Unsichtbares" in *umwelt* issue 4/2013, pages 46—49). Frequently repeated 3D images of snow cover also help provide increasingly better predictions of the expected snowmelt runoff and available water supplies. The Swiss Federal Institute for Forest, Snow and Landscape (WSL) is now working intensively in this area of research.

In the meantime, 3D applications have become not only more scientifically, but also economically successful. For instance, SenseFly and Pix4D, two spin-offs from the University of Applied Sciences in Lausanne (EPFL), have created a sensation: In 2013, they developed a three-dimensional model of the Matterhorn using mini drones. "We wanted to show what these devices are capable of in extreme conditions", explained Jean-Christophe Zufferey, CEO of SenseFly. Since then, technology has come so far that several drones could operate as a flock. They are used in agriculture and environmental monitoring to research sea turtles and for humanitarian aid. The UN Institute of Training and Research (UNITAR) used them in February 2012 to gain an overview of several neighbourhoods of Port au Prince, as Haiti's capital city is still in a dire situation after the huge earthquake in 2010.

"We wanted to show what mini drones are capable of in extreme conditions."

Jean-Christophe Zufferey, CEO SenseFly



Using technology for specific purposes

A lot of hype has been created around the drones in the last few years and is also noticeable in environmental monitoring. In FOEN expert Tom Klingl's opinion: "It makes sense to use the technology for local research, such as when monitoring a small mire site." Charlotte Steinmeier, expert in remote sensing at the WSL, agrees with him but adds that small aircraft are not as useful in taking images of large areas. Some of the reasons for this are their limited battery power and the legislation: Drones may only fly within eyesight, which means they must always be within the sight of their operator.

In Charlotte Steinmeier's view, the good aerial images produced by Swisstopo, for example, should be used rather than the drones and be complemented by satellite data. "And we have to ask ourselves what we really need to monitor land in a modern way." This does not necessarily involve continuously improving the resolution of the images. It is more important to take images more frequently.

New ground

Markus Wüest, Head of the Environmental Monitoring Section at the FOEN, also acknowledges that new and best monitoring methods need to be combined in a balanced way. "Measuring pollutants by satellite does not make our current monitoring network obsolete, but can be combined with it and used for early warning", he is convinced. This also applies to other areas such as forest and water.

In addition, there are some promising developments in terrestrial environmental monitoring that should be pursued. "Many well-known technologies such as laser, radar and pollution sensors are becoming increasingly cheaper; this is opening up new opportunities for research", says Markus Wüest. The crowdsourcing aspect, where information is acquired from many different little sources, is also exciting: "There are cars that already measure air quality inside and outside the vehicle." It is only a matter of time before these data will be collected and used for a real-time warning system.

IBM's attempt to replicate human abilities in pattern recognition was visionary and could be very useful for interpreting environmental data. "The human mind is still far superior to computers when it comes to interpreting images", emphasises Markus Wüest. This is one reason why "manual labour" may still very often be required in the most modern satellite monitoring.

When asked whether innovations will be observed in soil monitoring, Markus Wüest changes tack from technology to politics. Soil quality will probably change very slowly. "Quantity should not get lost in all the discussion about quality!" According to Swiss land statistics since 1985, every year Switzerland loses around 35 square metres of arable land. Here, it is a question of spatial planning and policy. Ultimately, the following is true: Environmental monitoring only serves sustainable development if it is applied in concrete measures.

"We have to ask ourselves what we really need to monitor land in a modern way."

Charlotte Steinmeier, WSL

Additional links to the article:
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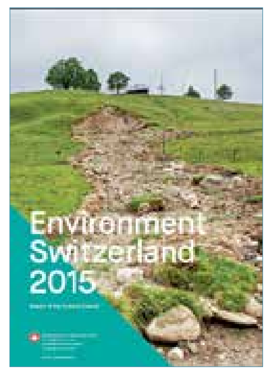
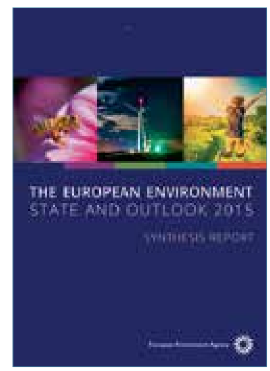
THE NEW ENVIRONMENTAL REPORTS

More Than Just Numbers

In 2015, the Swiss Federal Council will be the publisher of the environmental report for the first time as a result of the amendments to the Environmental Protection Act it adopted in June 2014 in connection with its accession to the Aarhus Convention. In doing so, the executive branch will provide the public with comprehensive and broadly supported information about the state of the environment. *Text: Lucienne Rey*





Anyone who wants to know how the key environmental statistics have changed in the last few decades would probably be better off delving into one of the environmental reports that have been published regularly since 1990. These reports have information on the percentage of organically farmed agricultural areas, changes in biodiversity, material and energy consumption by the Swiss population and general figures on the state of the soil, air and water. The indicators with traffic light pictograms provide an image of whether the changes are going in the right direction, i.e. green light, or a negative trend has continued despite efforts, i.e. red light.

A new report by the Federal Council

When its parliament ratified the Aarhus Convention in 2013, Switzerland agreed to submit a report on the state of the environment every four years. Since 2007, the FOEN has prepared an environmental report every two years for Switzerland, partially in cooperation with the Swiss Federal Statistical Office (BFS). The Federal Council is taking on this task for the first time with the Swiss environmental report in 2015. And because the executive branch is now publishing the report, an extensive consultation is required. Therefore, an official consultation was conducted with all of the federal offices involved. “This created new challenges for the entire team of authors”, explains Brigitte Reutter, Deputy Head of the FOEN’s Environmental Monitoring Section. “Nearly 100 people worked on the report, which had to be coordinated between them.”

The report makes a point of using reader-friendly language because it is ultimately intended for a wider public. “Its tone had to be adapted”, confirms Brigitte Reutter. Illustrations were also given a more prominent place than previously. Photos are now featured along with the column and curve diagrams to artfully represent the entire range of environmental issues and lend detailed precision to the published images.

Incorporated into international reporting

In the future, the Swiss environmental report will not be published every two years, but rather every four years. “We noticed that not much changes in two years”, explains Brigitte Reutter. The four-year cycle also meets the requirements of the Aarhus Convention. The European Environment Agency (EEA) publishes an environmental report every five years and puts the Swiss and other data in a European context. Two reports will actually be published in 2015: Switzerland’s environmental report in January and the European environmental report in April. They will provide an overview in differing scales of conclusions on the wide range of consequences that our lifestyle and economic system have on the environment.

Additional links to the article:
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Various bacteria with a preference for oxygen-poor environments create colourful mats on a lake bed; they have settled around the opening of a highly sulphurous underwater spring in a mountain lake. *Photo: Patrick Steinmann, AWEL*

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