WSL MAGAZINE

DIAGONAL

FOCUS

Boundaries: fixed or fluid

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Swiss Federal Institute for Forest, Snow and Landscape Research WSL

EDITORIAL

Dear Reader

Boundaries are clear dividing lines, sometimes even barriers, in the minds of us humans. In nature, such sharp boundaries are extremely rare. They exist – in snow, for example – but much of the time they are blurred and fluid. One such indistinct boundary is where water meets land and the two intermingle, as is often the case. Even the forest boundary is not a clearly defined line.

Nevertheless, we have precise conceptions of what a forest and what a field is, as well as what a village and what a city is. And we often draw clear boundaries between these different categories. These boundaries can then have an impact on the natural environment, such as when a forest stops abruptly at the edge of farmland or water flows through constructed channels. We then suddenly find sharp boundaries in nature as well.

But we must not forget that boundaries often have to do with the way we think in categories. Many 'boundaries' are constructs in our minds, as this edition of Diagonal shows.

We must be aware of this tendency to categorise, so that we can, among other things, handle boundaries constructively.

Christoph Hegg
Deputy Director WSL

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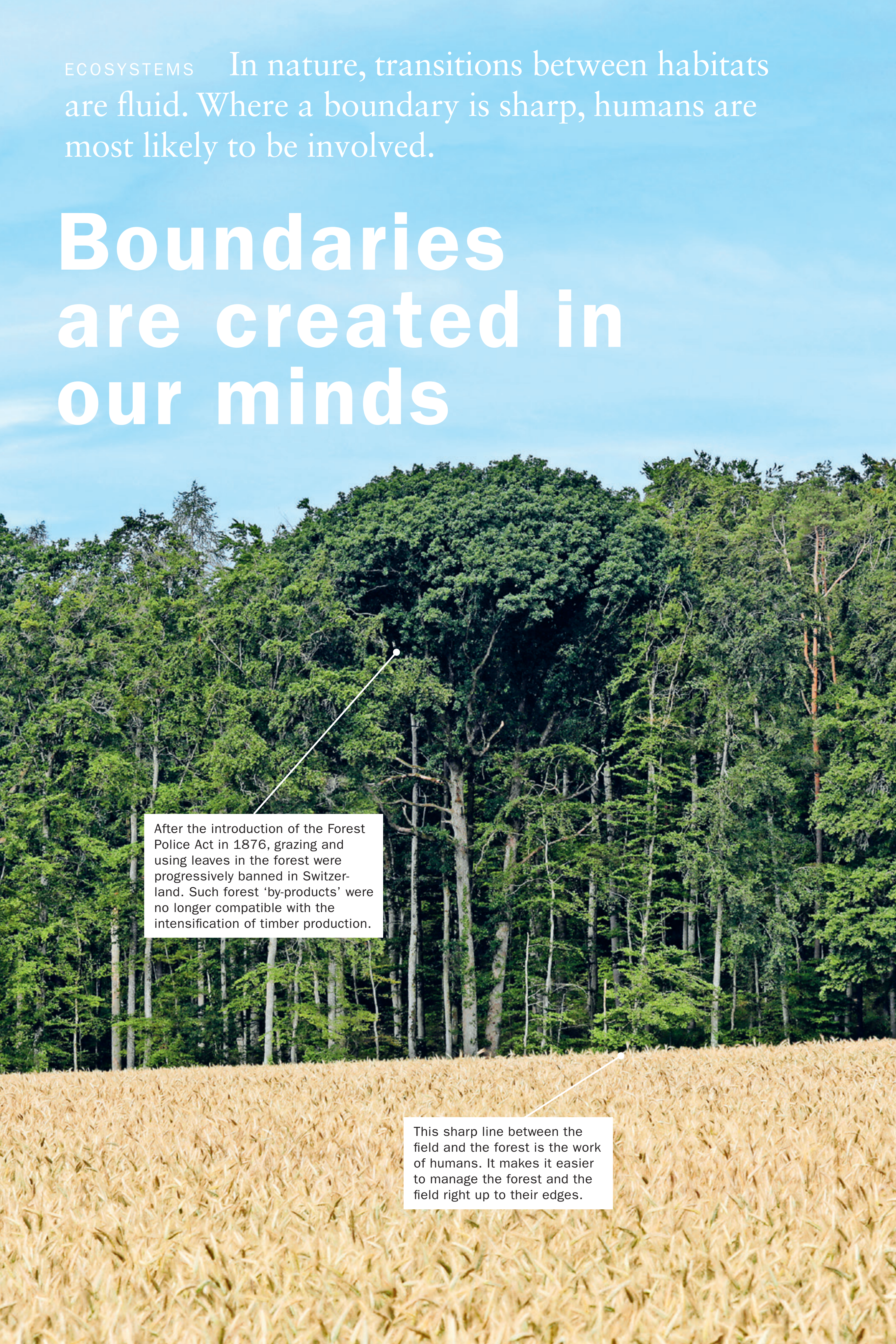
Boundaries

Photos: Cover: Valentin Moser, WSL; table of contents: Snow: Bruno Augsburger; Ecosystems: Markus Bolliger; Mountain forest: Marcel Giger; Species: Eric Gehring, WSL

ECOSYSTEMS In nature, transitions between habitats are fluid. Where a boundary is sharp, humans are most likely to be involved.

Boundaries are created in our minds



After the introduction of the Forest Police Act in 1876, grazing and using leaves in the forest were progressively banned in Switzerland. Such forest 'by-products' were no longer compatible with the intensification of timber production.

This sharp line between the field and the forest is the work of humans. It makes it easier to manage the forest and the field right up to their edges.

A forest that is clearly separated from open land appeals to many people because they can then use the forest edge more easily. Stepped forests with a transition zone, however, are better for biodiversity, as they provide many species with habitats, shelter and food.

Stetten in Canton Schaffhausen

Photo: Ulrich Wasem, WSL

The contrasts could not be greater: on one side is a flat and open field of corn, and on the other the closed forest, which is like a green wall of towering trees that contrasts marked by with the open field. The sharp boundary between the forest and the open land is clearly shown on the Swiss national map.

Of course, this hard boundary is anthropogenic and not natural. It was created to make farming and forestry more economic and efficient. "The Swiss Forest Police Act of 1876 provided a basis for professionalising forestry across Switzerland," says Matthias Bürgi, head of the 'Land Change Science' Research Unit at WSL, who studies landscape history. "The law regulated how the land was to be used, with conditions and responsibilities clearly specified, and allowed cultivated land to be used more intensively for forestry and agriculture." This is how the phenomenon of having clear boundaries between forests and fields first arose – and changed the landscape.

If the transition between open land and forest is left to nature, it will be more gradual and much less abrupt. There will be a herbaceous fringe with grasses and meadow flowers along the edge of fields, followed by a belt of young trees and shrubs, and then the forest mantle, which consists of adult as well as old or dead trees. Each section in the transition zone will be interwoven with the adjacent one. This transitional area between two ecosystems is called an ecotone, and is also constantly changing. Unless interventions are made, shrubs will spread out onto the open land, which will then become overgrown and eventually turn into forest – at least in Central Europe.

The biodiversity in such a natural forest edge tends to be much higher than inside the forest, as a WSL study in the 1990s showed. It provides – at least close to the ground – a habitat for around four times as many plants and twice as many insects and spiders as the forest. This diversity is possible because light and shade, and warmth and cold alternate within a confined space in the border area between the open land and the forest. "The variation in the site conditions there allows species with very different habitat requirements to thrive," says Martin Obrist, a zoologist involved in the study.

This is why the researchers found in this ecotone not only insects that are considered forest species as well as those that occur predominantly in open land, but also species that live exclusively along the forest edge. "A forest edge is not just an overlap zone, but a habitat in its own right," Martin explains. The transition zone also serves as a refuge for many animals. For example, insects take shelter here when the adjacent field is ploughed up or harvested. "The results have shown how important natural forest edges are as refuges for biodiversity in cultivated land," says Martin.

For more information on the Blue-Green Biodiversity research initiative, see: *wsl.ch/en/bgb*

Transition areas are attractive

Places where two ecosystems meet are not only popular with animals and plants, but often with people as well. This is especially true for bodies of water. In 2020, Marius Fankhauser, a social scientist at WSL, conducted a survey of people living in the Glatt Valley for a study that was part of the Canton of Zurich's 'Fil Bleu Glatt' improvement project (see Diagonal 2/21). The focus was on the role of the river Glatt as a local recreation area, and whether and how they wanted it improved. "The Glatt is important for people. They like to go there to linger or to explore its banks," according to Marius. Having attractive places to spend time along the river banks and safe access to the water is valued highly, and children and young people in particular want to have places to swim.

In this respect, the transition between forest and open land is similar. Here, too, it is important to have facilities that people can use, such as a bench with a view. But people prefer a forest that is clearly separated from the open countryside rather than a stepped, natural forest edge, according to studies conducted by WSL in the 1990s. "It's more difficult to use a natural forest edge as it is impenetrable," Marcel Hunziker explains. He is head of the 'Social Sciences in Landscape Research' Group at WSL and supervised the work. Another reason is that: "A forest edge with overhanging trees makes people feel secure, and allows them at the same time to have an unobstructed view of the landscape. This makes it inviting and people want to linger there. That's why they prefer having a clear boundary."

Interconnected systems

Sharp boundaries can be found not only between ecosystems but also between scientific disciplines. For example, processes in water and on land are often studied separately. This is something researchers at WSL and the Eawag Water Research Institute would like to change, which is why they launched the 'Blue-Green Biodiversity (BGB)' Initiative in 2020. "We want to integrate biodiversity research on land better with biodiversity research in water, and be able to

Valentin Moser is investigating, as part of his doctorate, how beavers change their habitats.
His project is part of WSL and Eawag's 'Blue-Green Biodiversity BGB' Research Initiative

combine proposed measures on how to preserve and promote biodiversity in both habitats," says Catherine Graham, an ecologist at WSL. She is leading the initiative together with Florian Altermatt from Eawag.

In the real world there is also a lively exchange between aquatic and terrestrial habitats. Amphibians, for example, live as larvae in the water, but when they are adults, they normally also make use of the adjacent habitats on land. Leaves that fall from the trees into the water are an important food source for microbes, aquatic insects and fish. And beavers 'beavering away' reshape entire banks, which has an impact on the living organisms in the water and on the land, as well as on the material and energy flows in both systems.

Initial results of the BGB Initiative have provided insights into the many interconnections between the two ecosystems. For example, one of the research projects showed that songbirds often feed their young with aquatic insects as they are more nutritious than terrestrial insects. Another study found that creating new ponds for amphibians is worthwhile so long as the water-bodies are well-connected over land.

"The causes of the current dramatic decline in biodiversity, such as climate change and intensive agriculture, are anthropogenic. To stop the loss, we need to look at both aquatic and terrestrial habitats at the same time," Catherine says. And this means transcending the boundaries in our own minds. *(lbo)*

Photo: Luca Zehnder

LAYER BOUNDARIES IN SNOW **Reflections in infrared.** Snowpacks have layers. Determining their boundaries is useful – not just for avalanche warning services and winter sports. Researchers at SLF have developed a device to detect them objectively. DIAGONAL joined them for a test.

Slowly, ever so slowly, the sledge begins to tilt to one side. Lars Mewes jumps forward quickly to right it, while Benjamin Walter continues to pull the sledge behind him. Together, the physicists from the WSL Institute for Snow and Avalanche Research SLF in Davos struggle with their load through the deep snow below the Pischa ridge, lugging around forty kilograms of technical equipment.

Their most important piece of luggage is a black box – the SnowImager – which Martin Schneebeli and Benjamin developed. The researchers use it to detect layer boundaries in the snow. This is the name given to the boundary between two layers in the structure of the snowpack. They are formed either by new snow falling on top of old snow or by frost on the surface of a layer of snow freezing to form its own layer. Individual layers differ. They may, for example, have different densities and/or types of snow crystal. Knowing their boundaries and properties helps experts like the avalanche warning team identify weak layers. These layers may break either spontaneously or because pressure is applied to them, for example by a skier. There is therefore a risk that the snow lying on top of the weak layer will thunder down the slope as a slab avalanche. Avalanche forecasters usually still measure the snowpack by hand,

First, they have to shovel: Benjamin Walter and Lars Mewes dig a hole in the snow. On the right is the sledge, fully loaded with different measuring instruments.

Photos: Bruno Augsburger, Zurich

Taking measurements using infrared: the prototype of the SnowImager in action.

which is time-consuming. The SnowImager should help to speed up this process considerably. “And the resulting resolution is up to ten times as high,” Benjamin says – and also more objective.

Before they can take measurements, however, they have to shovel. Lars and Benjamin dig rhythmically in unison. The snow crystals on the slope reflect the glistening sunlight. The researchers hit the bottom after digging down hundred and thirty centimetres. They widen the hole and – as a last touch – Benjamin smooths one side of the pit using a saw, trowel and brush. “The surface must be flat before we can start measuring,” explains Lars.

From research to application

At last they are ready. The scientists take the SnowImager off the sledge. Then everything happens very quickly. Starting at the bottom, Lars holds the box against the snow wall several times until he gets to the top. All in all, it takes barely more than two minutes. Light-emitting diodes project infrared light, invisible to the human eye, onto the snow wall. Two small cameras in the SnowImager measure how much of the light the snow crystals reflect. The smaller the crystals are, the more light comes back. The SnowImager then takes a second pass – this time, an aperture with a slit covers its front. “This allows us to determine not only the size of the snow crystals, but also the density of the individual layers,” Benjamin explains. The lower the density, the further the light penetrates into the snow layer. And the deeper it penetrates, the more it spreads laterally as the crystals reflect it. But the cameras only measure the portion of the light that comes back through the slit. Combining both values yields an analysis of the structure of the snow cover.

Developing the SnowImager has been a long haul – which just shows how important basic research is. Martin Schneebeli first heard about infrared films during the 1970s, when he was a teenager with a passion for photography. But

more pictures:

it wasn't until 1995 that he had an opportunity to try them out. By then he was already doing research at SLF. Equipped with a camera and infrared film, he set off with a colleague for the Flüela Pass. "The idea was to represent a snow profile in colour in order to distinguish the different shades of grey," Martin recalls. The attempt was successful, and the layers were clearly visible. The first doctorate on the subject was completed between 2005 and 2007. Later a device was developed to determine the size of the snow grains, but measuring the density continued to require tedious manual work. "It was only during the Corona period that we had a brainwave and realised: 'Eureka! The solution is to have a slit in front of the snow profile!'", says the former head of the 'Snow and Atmosphere' Research Unit at SLF. The idea for the SnowImager was born, and Benjamin set to work.

Ready for series production

On the first of February – a sunny day – Mirjam Eberli and Simon Grüter, from SLF's avalanche warning service, go to an off-piste slope in the Parsenn ski resort near Davos. There they also first have to dig. But when the hole is finished, things don't move as quickly as they did for Lars and Benjamin. They need to use a ram probe to see first how firmly the snowpack is compacted. Simon then runs his index finger carefully over the snow wall they have dug out to feel the transitions from one layer to the next, and calls out their height to Mirjam. Next, they use a magnifying glass and grid to analyse, layer by layer, the snow crystals' size and type. Finally, they painstakingly determine the density of the entire snow cover. With this method, the results vary according to who takes the measurements because people assess the situation subjectively. This leads to slightly different results, but with the SnowImager, such fuzziness disappears. Moreover, it measures the density of each layer and the data it provides is therefore more detailed.

The SnowImager still weighs five kilograms, but in the future, it should become handier and lighter, and thus suitable for everyday use – and ready for series production. Davos Instruments would like to produce the SnowImager locally. The project team believes there will be a demand in the long term for up to six hundred units in Switzerland alone, and talk about having the first portable and, at the same time, affordable device for measuring layers in the snow. The target group includes not only the avalanche warning services. Experts who determine when and where floods are imminent take into account the structure of the snow cover. Climate researchers can gain insights into climate change. Professional athletes use the data to help them choose the right equipment.

At the end of their day out measuring, Lars and Benjamin still have another strenuous task to do. They have to painstakingly fill in the hole they dug again. As Benjamin explains: "We wouldn't want a free-rider to fall in it and get hurt." *(job)*

Double page p. 10/11: Marco Walser, WSL

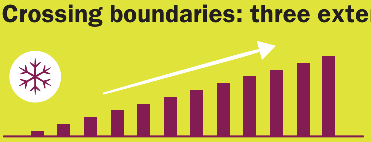
INFOGRAPHIC **It's time for leaves!** But how does a tree know it's spring and it can safely open its buds? By monitoring three environmental factors – and reacting when the species' own threshold values are exceeded.

The European beech in the course of the year

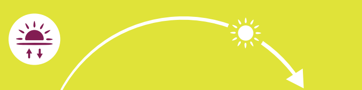
The plant year transcends calendar boundaries and has ten seasons. For the most common Swiss deciduous tree, the European beech, three factors are important: the cold period, day length and temperature:

Cold period Day length Temperature
(Details: see below)

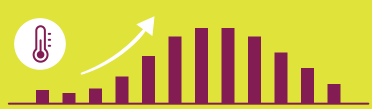
Crossing boundaries: three external factors influence when buds break open.



Cold period
In winter, our native trees 'count' the cold days. For many species (including the European beech), cold means temperatures below ten degrees Celsius. An overly warm winter may weaken species that need many cold days and delay budburst – unless the spring is also warm.



Day length
The length of the days and nights can also influence when buds burst. With the European beech, for example, budburst only occurs when days are at least twelve hours long. For native oaks, however, this environmental factor is not important.



Temperature
Spring temperature is one of three factors influencing the budburst of European beech, but it is the decisive one in the case of native oaks. They are therefore likely to have a head start over the beech in a warmer future.

The influence of these three factors has been well researched, but we still do not know what happens inside the buds while they are dormant in winter – which is why we are studying them.

Infographic: Michael Stünzi and Daniel Röttele, infografik.ch; Data and text: Stephanie Kusma, Manuel Walde, Yann Vitasse, WSL

In the soil of the former floodplain of the Albigna River, the deposits of past floods can be clearly seen. Grey sand and ochre-coloured clay layers alternate. The lowest layer contains large stones that were deposited during flooding.

At WSL, we are studying and documenting the physics, chemistry and biodiversity of soils. Our soil archive, with samples from all over Switzerland, and the database linked to it are important tools for our research. By collecting soil samples at regular intervals from the same sites, we can track how climate change and anthropogenic substances alter soils in the long term. Our findings are useful for protecting soils and the environment.

The grass roots in the top layer stabilise the soil and protect it from erosion. The dark brown colour of this layer comes from humus, which stores a lot of carbon. Generally speaking, soils store more carbon worldwide than the atmosphere and vegetation combined.

Soil of a former floodplain near Vicosoprano in Bergell, Canton Grisons.

TREE GROWTH **Above the timberline.** Mountain forests are expanding – but not at the same rate everywhere. Researchers at SLF are trying to find out why.

Twice a year Esther Frei climbs the slopes of the Stillberg in the Dischma Valley near Davos. She carries measuring instruments in her backpack up there not for pleasure, but as part of her job. Ten years ago, the plant ecologist at the WSL Institute for Snow and Avalanche Research SLF in Davos set up three experimental sites on the slopes between 1900 and 2400 metres above sea level: one in the mountain forest, one at the timberline and one 300 metres above it. While there, she also planted larch and spruce seeds. Since then, she has had to visit the sites many times. In June, she counts seedlings and puts up protective fences. In October, she surveys the plants as well.

Her results so far show that the seeds planted in the forest did not stand a chance. After two years, all the seeds and seedlings had been eaten or had died because of strong competition from other plants. “The vegetation also impeded germination at the timberline,” Esther says. In the long term, however, most of the small trees there have survived better than at the other sites. It was at the site above the timberline that the largest number of seedlings sprouted. The harsh conditions prevailing there, however, led to all the spruce disappearing within four years and only a few scattered larch seedlings have remained.

For further information, see: *slf.ch/treeline*

The timberline does not mean that no trees grow above it. It indicates the height above which no more forest grows. The treeline is higher up, explains Peter Bebi: “Individual larches may even be found several hundred metres higher.” He is head of the ‘Mountain Ecosystems’ Research Group at SLF, of which Esther’s project is a part.

The Stillberg has been a research site since the 1950s. In 1975, employees of the two forerunners of WSL and SLF planted 92,000 Swiss stone pines, mountain pines and larches there at altitudes between 2075 and 2230 metres above sea level. The aim was to find ways to improve protection against natural hazards, …

Photo: Walter Schönenberger, WSL

Like the treeline, the timberline is also moving up. It has been rising in the Dischma Valley for a good hundred years, and has risen in the past forty years alone by an average of ten to twelve metres per decade. "The timberline has changed most in areas where the intensity of cattle-grazing has greatly decreased," says Peter.

But climate change is also contributing to the shifting of forest boundaries worldwide. They are, for example, moving upwards and towards the poles. Esther's research forms part of the international G-TREE project (Global Treeline Range Expansion Experiment), where the influences on tree germination at the timberline are being investigated at locations ranging from Australia to Alaska.

It's not only the temperature that counts

It is not enough to simply take the development of the temperature into account, Peter explains, even though it has the greatest influence. "Other factors such as competing vegetation, the duration of snow cover, nutrients, wind, solar radiation and frost events all have an impact on tree growth."

In addition, animals threaten the young plants through browsing or trampling on them. Esther has protected half of the seeds she planted from this danger by covering them with metal grids. For her analysis of the effects of different conditions, she can refer to many different experimental plots, including those with no protection against grazing, artificial sowing or vegetation.

Where the forest spreads, it can provide better protection against natural hazards such as avalanches and rockfall. The consequences for plant diversity, on the other hand, may be rather negative. This is what a team led by Christian Rixen, an ecologist at SLF, is currently studying. "We assume that the spread of mountain forests will lead to an overall reduction in plant biodiversity as, unlike in forests, species occurring in fens and dry meadows are declining." *(job)*

Photo: Esther Frei, SLF

... 40 years later: metal grids protect young, newly sown plants from being eaten by animals on an experimental plot at an altitude of 2410 metres.

INVASIVE SPECIES **Species know no national borders.** The number of unintentionally imported plants, animals and fungi is increasing dramatically due to global trade. Controls at national borders are not always sufficient. WSL is helping to detect introduced species.

International travel and trade are leading to more and more non-native species entering Switzerland, such as beetles in the wood used for packaging or fungal spores in potting soil and on exotic garden plants. If they spread uncontrollably, they are referred to as invasive species. Of the approximately 1300 alien species known in 2022 to have become established, one in six is considered invasive. Combating them is expensive – if not impossible. WSL researchers are working on ways to detect them as early as possible and – where possible – stop them.

The most efficient way is to detect such organisms directly through border controls at the national border, and then eliminate them. This is not, however, always successful. Moreover, many also manage to migrate without human help. Until a few years ago, pests or diseases were therefore often only spotted when they were detected by chance or through targeted surveys in the country. The Asian long-horned beetle, for example, which is dangerous for many native tree species, has been found several times by chance in Swiss gardens. It probably got there from Asia with wood used for packaging.

For further information on forest protection in Switzerland, see: *wsl.ch/forest-protection*

Many countries are therefore introducing comprehensive and regular pest surveys. WSL tested this approach in Switzerland between 2020 and 2022 as part of a pilot project with the support of the Federal Office for the Environment FOEN. Cantonal forest protection officers regularly monitored test sites near urban areas in six cantons to detect eight harmful organisms that are particularly dangerous – so-called 'priority quarantine organisms'. The cantonal forest protection officers checked focus trees to see if they had disease symptoms, and collected insects and fungal spores from dedicated traps. The organisms they found were then determined by the WSL researchers.

During the three years of the trial, none of the species they were monitoring were found, but they did discover other introduced organisms, including another longhorned beetle species from Asia. It is still unclear how dangerous it is. "This finding shows that such monitoring sites are useful for detecting harmful new organisms early," says Valentin Queloz from the Swiss Forest Protection Group at WSL. The Group supports state and cantonal authorities in combating tree diseases and invasive forest pests.

The pilot project was promising, which is why pest surveys will be set up nationwide by 2025. Benno Augustinus, an insect researcher at WSL, estimates that around one hundred such sites will be needed for effective monitoring throughout Switzerland.

First, however, the organisms the authorities need to keep an eye on must be selected. Here so-called 'sentinel plantings' can help. At WSL, for example, a site with European plant species that are often exported to the USA has been

Tree-of-heaven and paulownia trees (on the left) – as here in Ticino – grow very quickly in open areas. That's why keeping, for example, power lines clear has become more expensive.

set up. The researchers at WSL regularly check these plants to see whether they harbour any local pests that could reach America with the plants and cause problems there.

Exotics on the move

Plant traders are, of course, obliged to guarantee that their plants are healthy. But even healthy plants can cause problems if they, for example, escape over the garden fence. At the WSL site in Cadenazzo in Ticino, researchers are therefore studying the tree-of-heaven, the paulownia and the Chinese windmill palm, which is sometimes incorrectly called the 'Ticino palm'. All three species have spread over large areas in the local forests.

These exotics grow faster than native tree species and game browse on them less, which means they often become dominant. This can interfere with some of a forest's desirable functions, such as providing protection against natural hazards. Windmill palms, for example, have thin roots and do a poorer job of stabilising steep slopes than native trees. The risk of slopes slipping therefore increases, as WSL researchers demonstrated in one part of the federal government's 'Adaptation to Climate Change' pilot programme.

With further climate change, it is likely that the problems caused by the often heat-loving exotics will get worse. Researchers at WSL are therefore working with the local authorities and foresters to develop strategies for dealing with the unwanted invaders or, if possible, get rid of them altogether. "Our goal is to offer realistic solutions for the particular region," says the WSL researcher Eric Gehring. *(bki)*

Photo: Eric Gehring, WSL

A very diffuse boundary. Is it possible to separate the city from the countryside and say what is one and what the other? Yes, says Marco Pütz, a researcher at WSL. Nevertheless, he explains, the notion of an urban-rural divide is wrong.

Marco Pütz, where is the urban-rural divide?

In the past, it was marked by a moat stretching around a city directly in front of the city wall. Today, it most often appears as a line or boundary when people vote on issues because those living in cities like Zurich, Lausanne or St. Gallen frequently vote differently from those living in the rest of the canton. The results of the voting are recorded on a map showing each municipality, which inevitably gives the impression of a clear boundary between the city and the surrounding area. In reality, however, there is no such dividing line. The boundary between the city and the countryside is a diffuse area, with interconnections criss-crossing it. The notion of the urban-rural divide is just that – a notion. The divide does not really exist.

What does this mean? Can't we say: this is urban and this rural?

Yes, we do it all the time – in our everyday language, for example, or in the media. It helps when talking about places and their characteristics. If you say "I live in the city" or "I live out in the country", it conveys more information than "I live in municipality X". What sometimes gets lost, however, is an awareness of the fuzziness of this classification. Whether we refer to a place as urban or rural has to do with, among other things, its past, including whether it ever had the right to call itself a city. It also has to do with how it sees itself and how people from outside look at it. Albisrieden, for example, has been a district of Zurich for almost a hundred years. Nevertheless, people living there take the tram "into town". It has a village centre with a church square and an annual cattle show, and a sense of community like that of a village. So drawing clear boundaries is not very easy.

But we draw them anyway.

Yes, because boundaries are necessary. When planning areas for subsidies and for infrastructure, such as hospitals, and distributing them fairly across the country, we distinguish between urban and rural areas more in the sense of how central they are. Solving structural problems in rural areas involves being selective and saying: you belong, but you don't.

And how do you draw the line?

There are various methods for this. In one you reflect on what distinguishes the city from the countryside. For example, rural areas are typically agricultural. The number of jobs in the primary sector, namely in agriculture and forestry, is a clear indicator, with more such jobs

Marco Pütz is an economic geographer and head of the 'Regional Economics and Development' Group.

How well a place is connected to public transport gives a clear indication of whether it belongs more to the city or the countryside. The picture shows the Julier Pass, Surses.

in rural communities than in urban ones. Another characteristic is how well connected a place is to local public transport. Zurich's Hardbrücke, where suburban trains arrive every minute, is clearly more urban than a place where a postbus stops ten times a day. The Federal Statistical Office FSO works with such indicators in its Typology of Municipalities. It distinguishes 25 types, ranging from 'core city in a large agglomeration' to 'rural peripheral mixed municipality'.

"The notion of the urban-rural divide is just that – a notion. The divide does not really exist."

Photo: Patrick Federi on Unsplash

In Switzerland, there are only five core cities: Zurich, Basel, Geneva, Lausanne and Bern. Examples of the other extreme include municipalities such as Albula/Alvra in Canton Grisons and Guttannen in Canton Bern. The FSO Typology also has 'intermediate' municipalities, with a mixture of urban and rural characteristics, such as Birmensdorf, which is also close to Zurich.

You mentioned that there are several ways to make the division.

Yes, another way is to refer more specifically to structures of land cover and land use, which is what the Landscape Typology of Switzerland does. The Typology was jointly compiled by the FSO and the Federal Offices for Spatial Development and the Environment. It distinguishes 38 landscape types without using the term 'rural' in its classification. But it does refer to the 'built-up landscape' around large cities and the 'urban landscape'. In addition, the FSO also records the Swiss Land Use Statistics, which do not include municipal data but rely on aerial photographs to determine what the land cover is: water bodies, buildings, roads, forests, fields or rocks. Four main consolidated types are distinguished: unproductive land, forest, agriculture and built-up areas. The types are further subdivided. A built-up area may consist of, among other things, areas reserved for traffic, for industry, for commerce and/or for housing, as well as recreational and green areas. These are all classified as belonging to a built-up area.

Why do we need so many systems?

They serve different purposes, and each has its own advantages and disadvantages. The Typology of Municipalities focuses more on people, while the Land Use Statistics takes humans only indirectly into account, for example by referring to buildings. If you want to research environmental changes or observe how cities and regions develop, land use statistics are attractive because they show how the landscape changes. Typologies of municipalities, on the other hand, allow conclusions to be drawn about the economy and society. At WSL, we refer to these typologies and data a lot, for example when modelling landscape changes or analysing regional development. *(kus)*

Bild: Bruno Augsburger, Zürich

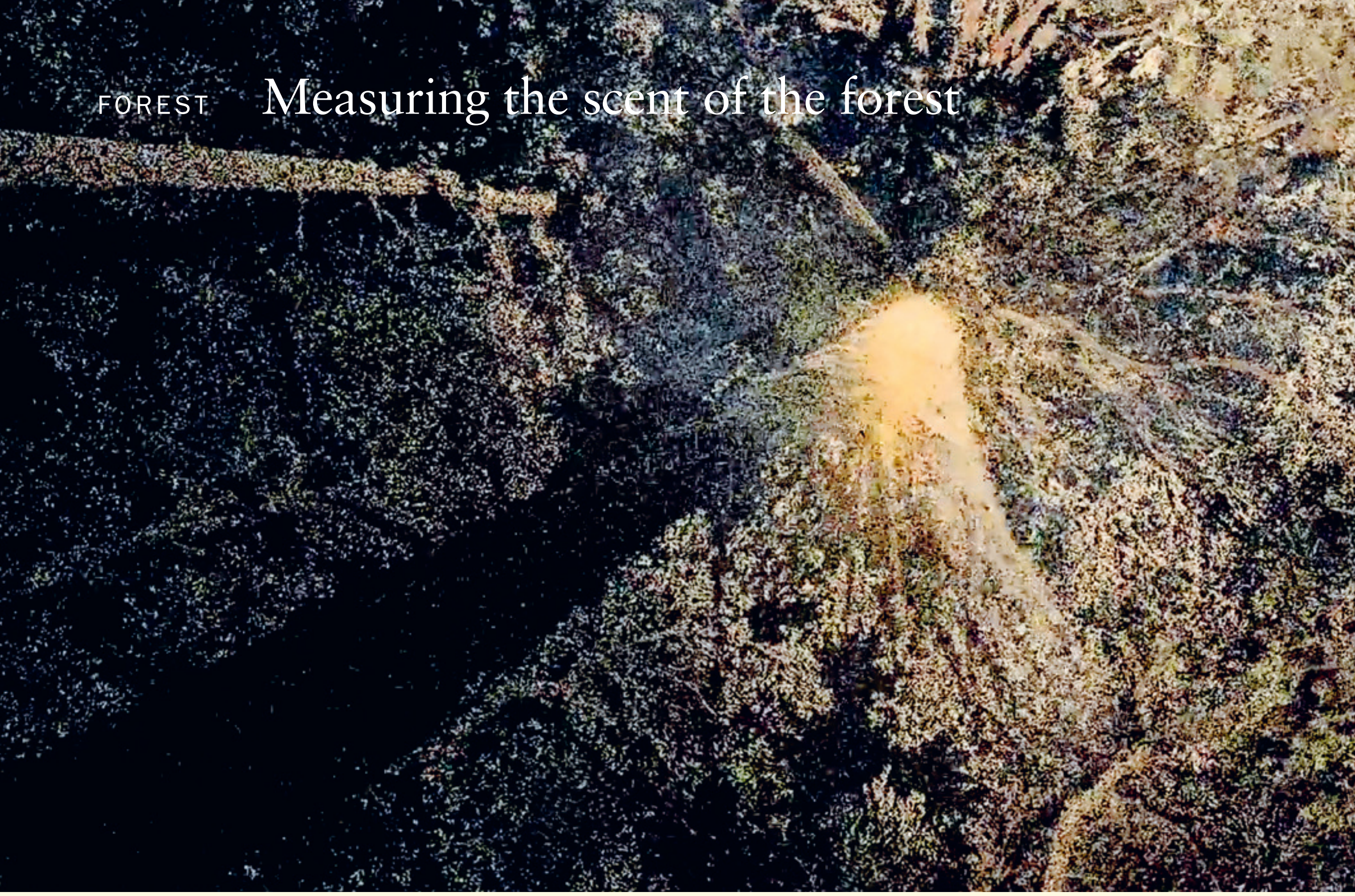
Valentin Moser, Birmensdorf

"The Sporn Nature Reserve in Allschwil is home to many different habitats, and you can find numerous species within a very small area. I always enjoy being here. It's where I learned to identify many different kinds of insects, amphibians and birds."

BEAVERS AS ECOSYSTEM ENGINEERS

Beavers change their ecosystems by actively felling trees and building dams. Other animals such insects, bats or even fish can then benefit from the resulting increase in light, deadwood and dammed water. Valentin Moser is investigating in his doctoral thesis how beavers' activities change species' compositions and associations as part of a 'Blue-Green Biodiversity' project, a joint research initiative of WSL and Eawag. "In this project, my knowledge of species comes in very handy." *(mlg)*

Measuring the scent of the forest



The art installation 'Atmospheric Forest' (2020) is a visualisation of the scent emission of pine trees in Pfynwald.

Photo: Image courtesy of the artists Rasa Smite and Raitis Smits, created in the SNSF project 'Ecodata – Ecomedia – Ecoaesthetics'

If you enjoy walking through coniferous forests, you will be familiar with their typical resinous scent. Sometimes you can even see the substances responsible for the scent with your naked eye in the form of a haze billowing above the trees. These organic compounds provide, however, much more than merely a treat for our senses – they are valuable for the trees and the forest community, and even affect the climate.

The substances emitting the smell are very volatile, which means they evaporate easily. "These volatile organic compounds have many interesting properties," says Arthur Gessler, a forest ecologist at WSL. Some are in the form of essential oils in the leaves, where they protect the cell walls against heat and drought stress and help to deter predators. They are released by trees when, for example, nibbling insects damage their leaves and bark, and serve neighbouring trees as early warning signs for pests.

Trees invest valuable resources in producing these protective and defensive substances, which is why they make only as much as necessary. But what happens if resources become scarce because the trees are stressed by heat and drought? To find out, the Finnish ecologist Kaisa Rissanen determined, together with researchers from WSL, the volatile organic compounds released by six Scots pines in a WSL research forest – the Pfynwald in Canton Valais – during the very hot summer of 2018. Previous studies identified the volatile organic compounds emitted by leaves, but this experiment was one of the first to capture those emitted by tree stems.

Defence against pests

The researchers were amazed at the large amount of scent that escaped

from the tree stems. "They emit about the same amount as leaves," says Arthur. "Whereas we had expected them to emit significantly less." Most of the compounds they found were monoterpenes. These are components of resin that help, among other things, to keep herbivorous insects away. With increasing drought, the trees' output of volatile organic compounds decreased overall, and their ability to defend themselves therefore probably also decreased. "But stressed trees seem to put relatively more energy into defending themselves against predators than trees with enough water."

During the experiment, there were repeated phases during which the trees released particularly large quantities of monoterpenes. The researchers suspect that the trees were reacting to infestations of insects such as bark beetles – even though they had observed no feeding insects directly. "Our study contributes an important piece in the puzzle and helps us understand better how more frequent dry periods affect forest trees," says Arthur, and explains: "The pines put their last efforts into defending themselves against insects, which are, in many cases, the death knell for weakened trees."

The new results are relevant not only for the health of forests. The organic compounds emitted from the stems and leaves of trees are extremely reactive and have both positive and negative effects. They promote, for example, the formation of ozone in the upper atmosphere and may prolong the lifetime of methane, a powerful greenhouse gas. But the particles also stimulate cloud formation, "Which means they can influence the local climate by, for example, cooling it down," says Ugo Molteni, a chemist at WSL. Such an effect is noticeable on, at most, a small scale in Pfynwald, but it is, according to Ugo, relevant on a regional scale in, for example, the huge coniferous forests in the far North. He is working on a project to investigate such climatic effects.

The breathing of the forest has even served as inspiration for art. With the help of the researchers, the artist duo Rasa Smite and Raitis Smits created a virtual reality installation 'Atmospheric Forest' to visualise the Pfynwald's scented landscape. In the three-dimensional model of the forest, the invisible gases 'bubble' out of the tree stems in the form of yellow beads – accompanied by atmospheric noise patterns. The video animation makes the drought stress of the pine trees both visible and audible. *(bki)*

vimeo.com/415663071

When forestry disturbs the aesthetics

Even forests with many visitors are managed – to obtain timber, for example, or to increase safety or biodiversity. People seeking recreation in the forest, however, tend to react negatively to extensive logging. Johanna Trummer from WSL's Research Group 'Social Sciences in Landscape Research' has studied the reaction of forest visitors to different forms of management.

Forest visitors do not appreciate major changes to 'their' forest.

She asked more than two hundred forest visitors in the forest laboratory on the Hönggerberg near Zurich to fill out a survey on tablets. They rated how well they liked differently managed parts of the forest they were in. The forest laboratory, which was co-founded by WSL, is a demonstration and research site for silviculture on an area of 150 hectares with various forms of management.

Her results show that forest areas with older and taller trees without gaps were valued most. These correspond not only to continuous cover forests in which only single trees are felled, but also to high coniferous forests with even-aged management. Freshly cut 'coppice with standards', on the other hand, was unpopular. This form of management, which dates back to the Middle Ages, involves felling younger trees every twenty to thirty years to obtain firewood and leaving single large trees such as oaks standing for up to a hundred years so that they can be used for timber. Many rare forest animals and plants, however, thrive in such sparse forests, which makes them valuable for nature conservation.

From the survey the researchers conclude that what the respondents rejected above all were large-scale interventions in the forest. "Anything that greatly alters what the forest looks like is poorly accepted," says the project leader, Tessa Hegetschweiler. It provokes negative feelings among people seeking recreation in the forest because they tend to identify strongly with 'their' forest. Although the information boards in the forest lab provide information about the 'coppice with standards' management form, this is apparently not enough to change people's reactions. The researchers hope that acceptance will increase if the foresters announce logging operations well before they are carried out and explain why they are doing them. *(bki)*

Photo: Martin Brüllhardt

LANDSCAPE

What is the risk of a vineyard in Ticino being abandoned? A new method is helping to find out

Wine-grapes can be found growing on over a thousand hectares in Ticino. Nevertheless, during the last thirty years, the area under vines has shrunk by almost forty per cent, as researchers at WSL's location in Cadenazzo have discovered. Traditional vineyards, where the vines are grown on pergolas, have been particularly badly affected. These steep plots of land are often terraced with dry stone walls and border on woodland, which is precisely why many of them are ecologically valuable.

Why are they disappearing? "The pressure on the wine market is increasing. If areas cannot be cultivated by machine, they soon become unprofitable. Moreover, in residential areas, building on vineyards, where permitted, is often more financially rewarding," explains Marco Conedera, a researcher at WSL. He is head of the project in which the researchers not only mapped the loss of vineyards, but also developed a method on behalf of Canton Ticino to objectively assess the effort involved in cultivating them as well as their value as cultural and ecological landscapes.

Each vineyard is, according to this method, evaluated on a point scale in terms of its accessibility by road, its slope and proximity to the forest. The area is then assigned to one of five categories according to the number of points it scored. A terraced vineyard that is on the edge of the forest, is difficult to access, and has to be worked by hand as well as protected from hungry deer, thus falls into the most difficult category. Cultivating it requires 'heroic' effort – and the risk that it will be abandoned within the next thirty years is over 65 percent.

In some vineyards in Ticino the vines are still trained to grow on traditional pergolas.

Photo: Marco Conedera, WSL

Another aspect of the method involves assigning points for the presence of dry-stone walls, pergolas or fruit trees to evaluate the vineyard as a cultural and ecological landscape. "With this method we can assess a vineyard comprehensively and objectively," says Marco. It enables the local authorities and decision-makers to get an overall picture of the situation and identify those areas they would like to conserve. One way to support conservation efforts could be providing targeted financial aid to maintain vineyards that are particularly difficult to cultivate, or that are culturally and/or ecologically valuable as landscapes. *(kus)*

“We need to build denser cities that still provide a good quality of life.”

Climate change, the energy transition and our more mobile society are changing the environment. Silvia Tobias, head of the WSL Landscape Centre, explains how landscape research helps to identify the associated challenges and find solutions.

Silvia Tobias, we find landscape all around us. Why should we study it?

Landscapes cannot be increased or consumed. But a landscape can be changed – and this may happen in a way that no longer meets people’s expectations. For a long time, urban sprawl has been an issue. Today, our research on energy landscapes is often in the news.

And what are the topics of the future?

In addition to energy, climate change is a big topic. It is already changing our landscapes. What exactly we do to prepare for these changes will affect the landscape in different ways. In one project, we show people possible scenarios to raise their awareness about this. Moreover, we are increasingly becoming a multicultural society and demands on the landscape thus vary greatly.

To what extent can landscape research help here?

Our residential areas must accommodate more people, with often very different cultural backgrounds, while still providing them with quality of life. At the same time, they should be able to withstand climate change because the more densely and higher we build, the hotter such areas become in summer. We need open spaces, i.e. green lungs where people can still breathe in a hot summer. This is why we are currently investigating how to make such green spaces as restorative as possible. How, for example, does street noise affect them? What features in a park help to make migrants feel more ‘at home’?

Have new ways of doing such research been developed?

Modelling has become much better and increasingly important. It allows us to show and explore possible developments in virtual landscapes. ‘Living or real-world labs’ are also innovative approaches, where researchers develop real projects on site together with local actors. The researchers provide expert knowledge and, in the process, learn which factors influence the success of particular projects. Within the ETH Domain, such a living lab is currently being ‘set up’ for sustainable development projects in the Jurapark in Canton Aargau. *(kus)*

This conversation is based on the Landscape Centre's conference on ‘Challenges for landscape research in the next 10 years’, where Beate Jessel, Adrienne Grêt-Regamey, Marcel Hunziker, Ulrike Sturm and Evelyn Coleman gave talks.

Silvia Tobias is an environmental engineer and head of the WSL Landscape Centre.

Photo: Gottardo Pestalozzi, WSL

LANDSCAPE

Webcam images help in assessing how grasslands are used from some distance away

The computer is good at detecting mowing events in satellite images. Images from webcams like this one in Adelboden Boden provide a useful reality check.

Intensive use of meadows and pastures tends to reduce biodiversity, as many species that cannot tolerate frequent cutting or heavy fertilization disappear as a result. The little data available up until now on how intensively grassland is used in Switzerland is, however, patchy, and normally only local. But such data would help to explain some of the changes in species diversity that have become apparent in biodiversity monitoring programmes.

Satellite images can help here, and are today available at high temporal and spatial resolutions. The computer uses these images to determine, with the help of an algorithm, whether and how often a grassland has been mown or grazed, and then creates maps of the use intensity. But do these maps correspond to reality? Dominique Weber, an environmental scientist at WSL, and his colleagues have found a simple method to check this. "Freely accessible webcams record not only the weather, but also what is currently happening at a particular place," says Dominique. The images show, for example, whether a grassland is being mown or cattle are grazing there.

The researchers compared these images with the maps generated by the computer, and found that the computer was good at identifying mowing when it took place, but not grazing. Dominique thinks: "We need more data to fine-tune the algorithm for this." The maps of use intensity could then be referred to, for example, when planning the Ecological Infrastructure. This is a network of areas important for biodiversity that should include extensively used grasslands to link protected areas. *(lbo)*

Photo: Hotel Alpina, bergfex.ch

Mushroom hunting for research

The WSL biologist, Artemis Treindl, records data for the macrofungi Red List – including here on a meadow at the WSL location in Birmensdorf.

Taking great care, Artemis Treindl picks up a small, whitish fungus from the ground. "A Winter Stalkball," the biologist exclaims. "The wart-shaped opening on its cap makes it easily recognisable. That's where it ejects its spores." Artemis found the puffball nestling among moss and stones on the WSL site in Birmensdorf.

The Winter Stalkball is classified as vulnerable on the Red List of endangered macrofungi in Switzerland. The 2007 list is currently being revised on behalf of the Federal Office for the Environment. Artemis is one of the WSL researchers working on this project, together with many volunteers. The aim is to collect as much information as possible on the approximately six thousand species of macrofungi known in Switzerland. "In the first Red List, it was only possible to evaluate the extinction risk of just under three thousand species. For the others there was too little data. We want to do better this time," she says.

The meadow on the WSL site is one of 634 sample plots where the experts systematically record fungal fruiting bodies and capture fungal spores from the air using specially developed spore traps. Half of these plots are deliberately located in areas where the fungal diversity is expected to be high. The others are randomly distributed across forests, where the plots are 100 by 100 metres, and across open land, where the plots are 200 by 200 metres. It takes about six hours on average to search a plot. "We are very glad to have the support of our volunteers. Without them we would never complete the work," Artemis says.

She records the details about the Winter Stalkball directly via an app on her mobile phone. Any fungi she can't identify in the field she takes with her to the lab – like the fungus

Photo: Lea Huber, WSL

she finds next – a *Galerina* species. She picks out a specimen in particularly good condition and places it in a small plastic box with various compartments where other mushrooms are already waiting to be identified in the lab.

More data thanks to genetic methods

In the laboratory, Artemis examines the *Galerina* under the microscope. *Galerina* species have special cells on the edge of their lamellae under the cap, so-called cystidia, which can be used to identify them. "This one has club-shaped cystidia with small heads. It's a *Galerina clavata*." Identifying the species under a microscope is time-consuming, but with genetic analyses it's quicker: "Genetic analysis enables us to process and determine a lot of specimens at the same time, and we can even generate new reference sequences for many species," she says. With this method, the researchers have already discovered more than thirty species that had never been identified in Switzerland before.

All the fungi and site information ends up in the database of the national data and information centre SwissFungi, which is based at WSL. The data is then publicly accessible. The fungi determined in the laboratory are dried and stored as specimens.

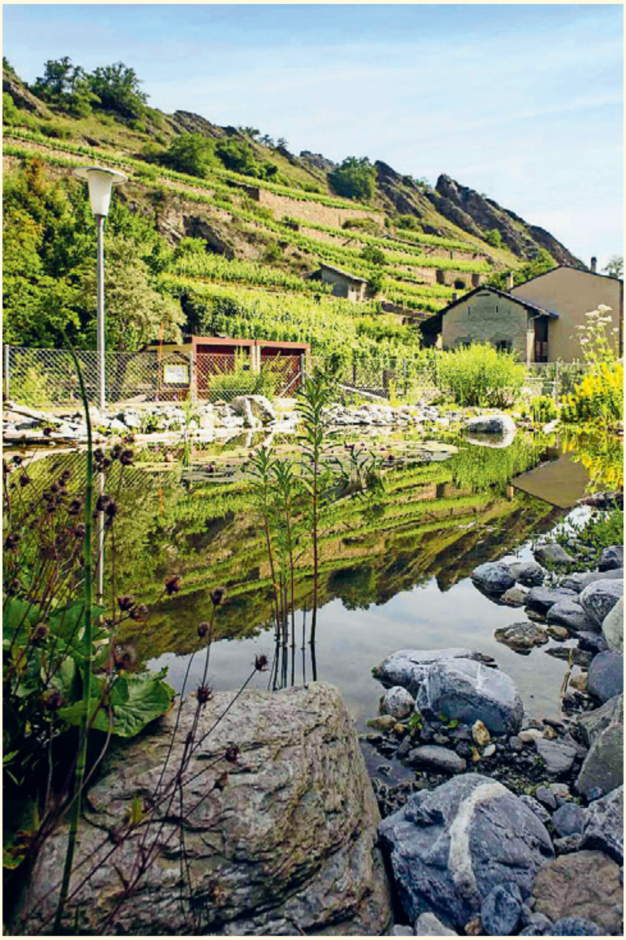
The field surveys are currently ongoing. All the data is being analysed and compiled for the Red List, with publication planned for 2025. On the 2007 list, one third of the fungi were classified as endangered. Whether the new list will contain more or fewer species remains to be seen. Some of the reasons why many fungi are becoming endangered are: habitat loss, overfertilization in agriculture and climate change. Moreover, as with animals and plants, new fungi species are migrating into Switzerland, where they may pose a threat to the native flora and fauna. "A lot of the things happening we can't see. As far as the actual diversity of fungi is concerned, we are still largely in the dark," Artemis says. Her work is helping to fill the gaps in our knowledge. *(lbo)*

The Winter Stalkball *(Tulostoma brumale)* ejects its spores from the warty opening on the cap.

Like most members of this genus, *Galerina clavata* can only be reliably identified with a microscope.

Photos: Markus Wilhelm

How to adapt to climate change better



Replacing a car park with a pond at a primary school in Sion improves the local climate.

Switzerland is, as an Alpine country, particularly affected by climate change: Temperatures here are rising more sharply than the global average. Melting permafrost and more severe storms increase the risk of natural hazards such as landslides or debris flows. Hot summers have serious health impacts and can lead to crops failing. But according to Dominik Braunschweiger, a social scientist at WSL, there is a gap between the concrete steps being taken to adapt and what is actually needed to be better prepared for such impacts of climate change.

One reason for this lack of preparation, says Dominik, is that "people only tend to consider adaptation to the impacts of climate change necessary if they feel personally affected by climate change." His case studies showed that only then do they see such events as the consequence of climate change and not just as sporadic natural phenomena.

Strategically well prepared

He has investigated how well Switzerland has adapted to climate change as part of the WSL research programme CCAMM. Strategically, it is well positioned as: "an action plan at the federal level aims to include adaptation to climate change in all its strategies and planning," explains Dominik. The problem is in the implementation because: "no political mandates for concrete measures exist." That in itself is understandable because, as he says: "the adaptations needed in Geneva differ from those required in Grindelwald. In cities, excessive heat is the biggest problem, while in mountain regions, changing natural hazard management, for example, or adapting tourism are more urgent."

Concrete measures should therefore be decided on by local stakeholders. This approach has been found to be effective in the federal pilot programme 'Adaptation to Climate Change', which finances projects on adapting to climate impacts. The city of Sion, for example, launched the 'Acclimatasion' project, in which, among other things, a school converted a car park into a wetland biotope and planted greenery on the roof. "This helps to mitigate the heat in the city," Dominik says: "and at the same time raise chil-

Photo: Ville de Sion

dren's awareness of the impacts of climate change."

The effects of such awareness raising should not be underestimated. In his research, Dominik found that informing and sensitising the public is one of the levers that could accelerate adaptation. "Making the colour of the outsides of buildings light can mitigate the impact of future heat waves. But those responsible must be aware that this is necessary." Other starting points identified in the successful pilot project include providing funding and ensuring projects meet with local acceptance. *(kus)*

wsl.ch/gov-vis-cca

NATURAL HAZARDS

Dangerous glacial lakes in the Himalayas: A new study may help prevent disasters

On the morning of 17 June 2013, pilgrims at the Kedarnath shrine in India's Kedar Valley heard a loud crashing sound. A few minutes later, masses of water swept down on them, washing away people, bridges and buildings and destroying the town of Rambara, eight kilometres further down the valley. At least 4000 people lost their lives. The cause: an outburst flood from the glacial lake Chorabari.

Such an event can occur if a meltwater lake bursts through the natural dam behind which it has collected. This could happen more frequently in coming years because glaciers are retreating and new lakes forming. As a result, the number of lakes held back by ice dams is increasing. A WSL team has recently estimated where such lakes could form in the Himalayas and how many are likely in the near future. The results should help local communities to plan more effective protective measures. Unlike in Switzerland, few glaciers in the Himalayas have been monitored systematically

The two satellite images show examples of glacial lakes (circled in red) held back by glacier ice. Such lakes may burst and flood lower-lying regions.

Photo: ESA Copernicus Sentinel-2

so far – there are simply too many of them.

Using an algorithm fed with data related to the surface, the ice thickness and the bedrock, the WSL team has calculated the possible locations of future glacial lakes, taking into account various scenarios for future global warming. The team, led by Daniel Farinotti, a glaciologist at WSL and ETH Zurich, and his former PhD student Loris Compagno, estimates that there will be around 11 700 such lakes by the year 2040. That is about 2500 more than in the year 2000. Taken together, the lakes could cover an area of 340 square kilometres and contain 2450 million cubic metres of water.

Dam failure

The researchers have focused their work on lakes that have formed behind ice dams because these are more dangerous than comparable dams formed from sediment. "Glacial ice can dam water, but it is not a particularly stable material for this," Daniel explains. "Dams made of ice can fail within a short time and release large amounts of water down into the valleys." The team are focused in particular on potential lakes with a volume of one million cubic metres or more. Lakes above this size are especially dangerous.

The results of the study have been made publicly available and provide a basis for planning protection and prevention measures. They can help, for example, to identify which buildings and infrastructure are at risk. Regular monitoring is also important for controlling risk. "Our study allows us to anticipate where possible lakes could form," Daniel says, but whether these lakes actually develop depends very much on local conditions. An NGO has already expressed interest in the study as it would like to provide support for the local communities. *(job)*

Photo: Bruno Augsburger, Zürich

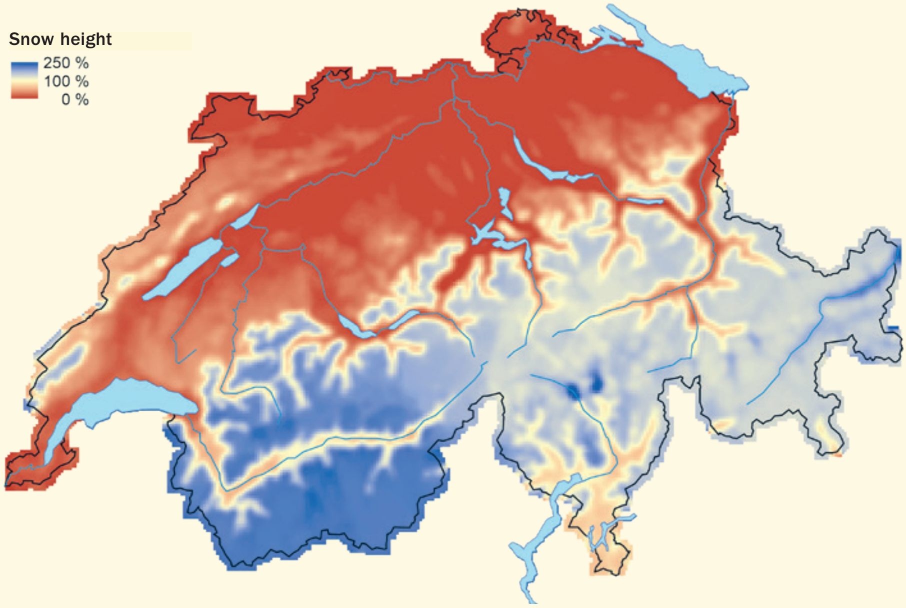
Armanda Pitschi, Davos

"We have no electricity and poor mobile phone reception in our lower-mountain-pasture hut (Maiensäss) in Partnun near St. Antönien. But the peace and quiet here and the wonderful view of mountains and lush meadows help me quickly forget everyday life. This is where I can really unwind."

IT SUPPORT FOR THE SLF

Armanda Pitschi works in IT at the WSL Institute for Snow and Avalanche Research SLF in Davos. She is mainly responsible for support, ordering computers and accessories, and installing software and hardware. "I like having direct contact with the staff and helping with technical computer problems." As a mother of two young girls, she appreciates being able to work part-time and one half-day a week from home. *(sni)*

SPASS with snow – thanks to old data



In the winter season 2017/18, snowfall in the cantons Valais, Ticino and the Grisons (shown in blue) was above-average, but in northern and western Switzerland (shown in red), it was much less than usual.

When is a winter really winter? A quick flashback to 2022/23 when the winter got off to a weak start: there was little snow in the mountains, and many ski slopes and cross-country ski trails opened later than planned or only after massive use of artificial snow. But was the situation in the different regions really exceptional?

As of next winter, this question will be addressed with the Spatial Snow Climatology for Switzerland, or SPASS for short, which means 'fun' in German. It draws on thousands of maps with a resolution of one kilometre that show how much snow there was when and where on each day since 1961. SPASS was developed in collaboration with the Federal Office of Meteorology and Climatology MeteoSwiss by a work group led by Christoph Marty, an expert on snow from the WSL Institute for Snow and Avalanche Research SLF in Davos.

The maps are not only interesting for researchers. "They help us draw conclusions about how much water will be available in the summer in the particular regions in Switzerland, as well as about where flooding could be imminent and where drought is likely to occur," says Rebecca Mott, a research assistant at the Operational Snow Hydrological Service (OSHD) at SLF. This information is, for example, relevant for farmers.

The OSHD uses weather data in modelling snow quantities throughout Switzerland. The work group adapted these values as the basis for SPASS and the resulting maps. The weather data is supplied by MeteoSwiss. In return, MeteoSwiss receives snow data from SLF and use the new SPASS maps to provide more information.

"For us climatologists, this data is important because we can use it to classify each winter," explains Christoph. The project is still in the trial phase, but it should start regular operation as early as the winter 2023/24.

(job)

Photo: Christoph Marty, SLF

Permafrost: More than half has already disappeared

Climate change is warming the atmosphere – and the soil. This is having consequences. The elevation of the shallow permafrost limit has risen by around four hundred metres since the 1980s. Moreover, as mountains narrow towards the top, the area permanently covered by frozen ground is shrinking all the faster. During the past forty years, three-fifths of the area has already disappeared and a further fifth is currently thawing, according to a new study of the WSL Institute for Snow and Avalanche Research SLF. The project leader, Robert Kenner, explains: “This decrease is just as dramatic as the retreat of the glaciers, but it is not visible. So far it has only been partially recorded in a short series of measurements.” Thawing can destabilise permafrost ground, and the loss of permafrost is more than just an exciting phenomenon: debris flows and rockfalls from thawing slopes are on the increase.

The air temperature is decisive

The longest ground temperature time series are not even thirty years old, so how did the researchers determine how much the permafrost area had decreased? Robert says: “We wanted to compare temperature data from different boreholes. This is not easy because the elevation and slope aspect both have a strong influence on the evolution of ground temperatures.” To ensure the comparability of the measurements, the researchers modelled the relations between the air temperatures, potential solar radiation and ground temperatures for each individual temperature sensor in the boreholes. By combining these values, they were able to calculate the elevation of a theoretical and universal zero-degree Celsius level in the ground – independent of radiation.

The researchers were surprised to find that it corresponds very well to the multi-year mean of the atmospheric zero-degree Celsius level in terms of altitude and temporal evolution. Other influences, such as snow cover, only affected the ground temperatures for a short time and in the uppermost layers. In contrast, the atmospheric zero-degree Celsius level is a very precise indicator for the temperature evolution at a depth of several metres. This finding opens up new opportunities for the researchers: “We can use decades of air-temperature measurements from meteorological balloon soundings to reconstruct earlier ground temperatures,” says Robert. The warming taking place high up in the mountains is significantly greater than the Swiss average, and has already caused the loss of three-fifths of the permafrost area. *(bio)*

Gian-Kasper Plattner, Birmensdorf

"I grew up in Riehen, two minutes away from the entrance to the Wenkenpark, where I often played as a child. Later, as a teenager, we had many parties there. Now we go there regularly with our children and friends. The Park has always played a part in my life."

COORDINATING RATHER THAN DOING RESEARCH

As a member of the staff at WSL, Gian-Kasper Plattner advises and supports the Directorate on, for example, strategic issues. The climate researcher and expert on the Intergovernmental Panel on Climate Change (IPCC) also represents WSL in organisations such as the National Centre for Climate Services NCCS, as well as managing the environmental data portal EnviDat and teaching. "I really enjoy having so many different tasks in the scientific community. It means I rarely miss working as a researcher, especially since I can often contribute my expertise." *(kus)*

Photo: Bruno Augsburger, Zürich

OUTLOOK DIAGONAL NO. 2, 2023

The burning sun beams down hot from the sky – and in the upcoming issue of DIAGONAL, everything revolves around heat. How does heat affect the lives of people, animals and plants and how does it impact our environment? What dangers do the ever more frequent heat days each year pose for us – and what opportunities do they offer? At WSL and SLF things also ‘hot up’ when researchers get to work on ‘burning’ issues – even if this cannot always be expressed in degrees Celsius!

Photo: Divesh Ray / CC0 Public Domain

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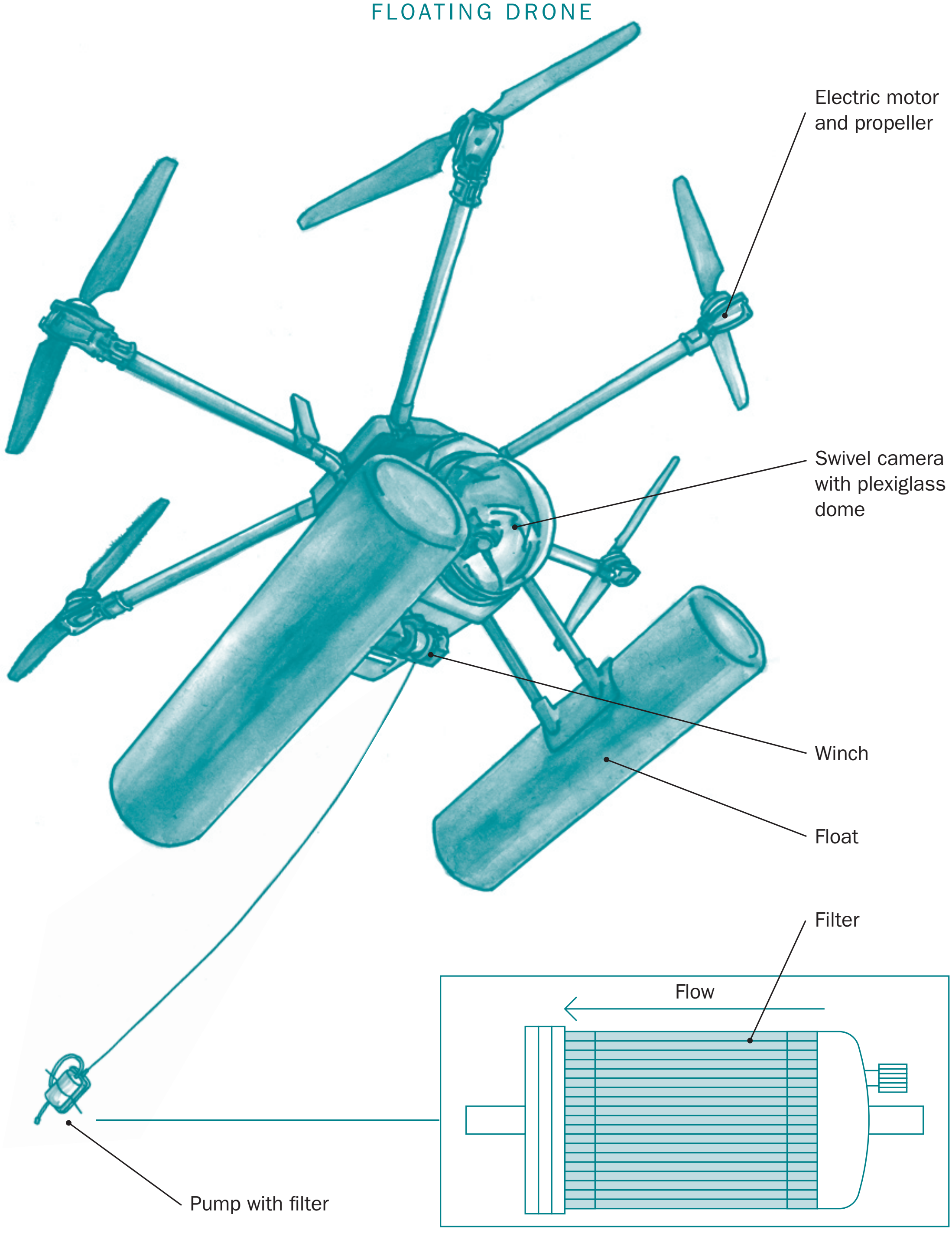
PEOPLE

The Diagonal editorial team, from left to right, top row: Stephanie Kusma, Beate Kittl; bottom row: Birgit Ottmer, Sandra Gurzeler, Claudia Hoffmann, Lisa Bose

FLOATING DRONE



Genetic material in a water sample can reveal what lives in a body of water. But what if a lake is inaccessible or no boat is available to collect samples? This is where a drone specially developed at WSL and the ETH Zurich can help researchers. Not only can it float on water, but it can also lower a pump with a filter on a rope into the water while flying. This allows large quantities of water to be filtered on site. The genetic material left by organisms in the water then accumulates in the filter. The researchers duplicate and decode this in the laboratory. By comparing it with already known sequences of genetic material, they can then determine which species the genetic material comes from. *(kus)*

Video at:
www.wsl.ch/object


Ecosystems: When boundaries blur, p. 2

Searching for mushrooms for research: Fruiting bodies of the shaggy ink cap, p. 26

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RESEARCH FOR PEOPLE AND THE ENVIRONMENT

The Swiss Federal Institute for Forest, Snow and Landscape Research WSL conducts research into changes in the terrestrial environment, as well as into the use and protection of natural spaces and cultural landscapes. It monitors the condition and development of the forests, landscapes, biodiversity, natural hazards, and snow and ice, and develops sustainable solutions for problems that are relevant to society – together with its partners from science and society. WSL plays a leading international role in these research areas, providing the basis for sustainable environmental policy in Switzerland. WSL employs more than 500 people in Birmensdorf, Cadenazzo, Lausanne, Sion and Davos (WSL Institute for Snow and Avalanche Research SLF). It is a Swiss federal research centre and part of the ETH Domain. You can find WSL's annual report online at: www.wsl.ch/annualreport.

WSL

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