WSL MAGAZINE

DIAGONAL

FOCUS

Research XXL: nature as laboratory

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Swiss Federal Institute for Forest, Snow and Landscape Research WSL

EDITORIAL

Dear readers,
We have decided on a ethodological focus in this issue, namely on large-scale testing. Often, research is possible only with the use of costly electronics, computers and mechanical devices. And with patience too – the patience to wait for the precise moment when an avalanche or a debris flow thunders down the testing site equipped with measuring sensors, or simply the patience to wait for trees to grow. With this focal point, we offer you an insight into this infrastructure-intensive branch of research. Attentive readers will note that the annual report customarily included in the early summer edition is missing. This is because we now conduct our accounts according to the International Public Sector Accounting Standards (IPSAS). IPSAS requires the publication of a comprehensive finance and business report. You will find this on our homepage at: www.wsl.ch/more/annualreport. The vacant pages will be devoted to further articles on our five main research areas.

I hope you enjoy reading this issue

Christoph Hegg
deputy director, WSL

Research XXL: Nature as laboratory

NATURE DETERMINES WHEN THINGS GET UNDERWAY
What happens inside a debris flow? When does a stream transport rock and debris? Large-scale experiments in mountain streams provide answers.
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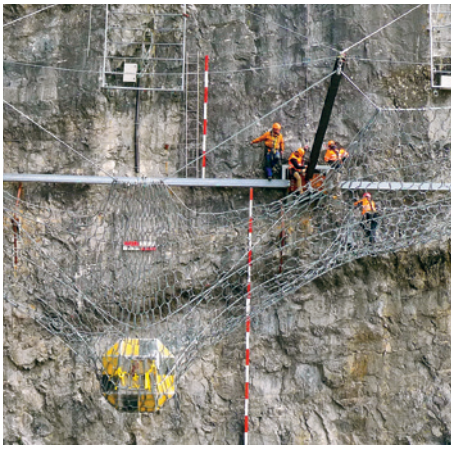

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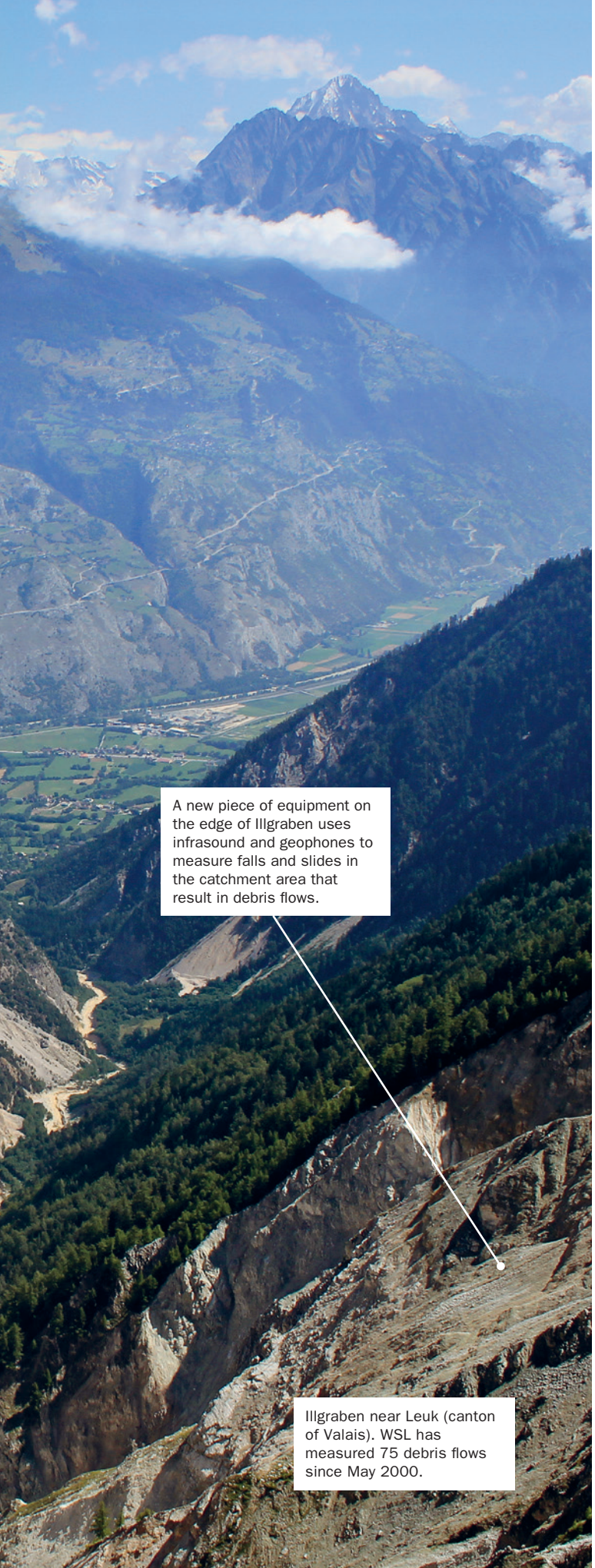
FOCUS What happens inside a debris flow? When does a stream transport rock and debris? Large-scale experiments in mountain streams provide answers.

Nature determines when things get underway

When it rains, the yellowish loose rock material mixes with water and becomes a slushy mass that slides into the valley as a debris flow. It also carries larger pieces of rock.



A new piece of equipment on the edge of Illgraben uses infrasound and geophones to measure falls and slides in the catchment area that result in debris flows.

Illgraben near Leuk (canton of Valais). WSL has measured 75 debris flows since May 2000.

Photo: Christoph Graf, WSL

The noise is deafening. A passing mountain biker stops and looks around in bewilderment. A sign under the flashing warning light warns: "Danger! Debris flows can occur at any time – even when the weather is good." Only when WSL technician François Dufour calls out: "Don't worry, it's only a test", does the biker continue riding along the almost completely dried up stream bed. No one thinks that the trickle between gravel and debris, in Illgraben near Leuk (Valais), will cause any harm. However, it can turn into a deadly wave of mud and water in a matter of seconds. When it rains, sometimes combined with snowmelt, hundreds of tons of mud, gravel and boulders thunder down into the valley as a debris flow. This sort of debris flow is more powerful than a flood with sediment and can cause a correspondingly high amount of damage. Thanks to the geological structure of Illgraben, several of these events occur each year, which makes it an ideal place to study debris flows.

A big open-air lab

Since May 2000, WSL has had a number of measurement instruments installed in Illgraben, including a geophone that measures seismic ground motion. The geophone records the vibrations that signal the beginning of a debris flow and automatically starts video recording. Radar and lasers record the flow height and speed of the mud and debris mass in several locations. At the outlet of the torrent channel, where the Illgraben flows into the Rhone, sensors in a side wall measure the forces inside the debris flow mixture. And underneath the bridge that carries the cantonal road, a scale records the weight of the material flowing past. →

"This location provides us with a unique opportunity to research the inner workings of debris flows: their composition, their flow behavior, their characteristics," explains technician Dufour. The data allows researchers to improve their understanding of the processes that occur during a debris flow and optimize computer simulations. This helps engineers and planners prepare hazard maps and assess any protective measures.

Warning system for villages and tourists

Dufour is an engineer and one of the technicians who also maintains the warning system in Illgraben, in addition to the scientific measurement devices. Inspections and maintenance work are required in particular after major debris flows. He has to take a different route to reach the measurement devices each time, as the dirt path is gradually falling victim to erosion. Today, he has to crawl over the rocky ground on all fours, using bushes and branches to lift himself up in order to reach the highest instrument.

WSL installed the warning system in 2007 on behalf of the municipality of Leuk/Susten. As soon as the warning devices register a debris flow, local security officials receive notification automatically via SMS. At the same time, visual and audible alarms signal the danger at three stream crossings. The findings of scientific observations and an emergency plan developed in conjunction with the municipality serve as the basis for the early warning system. In addition, in order to be able to detect a major debris flow in good time, rainfall in the catchment area is measured automatically and field surveys are carried out on a regular basis – by helicopter in extreme situations. In addition to its protective function, the warning system also serves as a pilot installation for the development of warning measures in other locations.

More about WSL's debris research in Illgraben: *www.wsl.ch/more/illgraben-en*

High above Illgraben, a radar measures the movements of landslides in the area. These landslides provide the material that makes up debris flows.

Photo: Brian McArdell, WSL

Debris flow or flood – it's all about the sediment

WSL also measures how much material may be carried in a stream in Alptal (Schwyz), albeit for a different reason. Here, it rains often and heavily, and as the soil is clay-rich, the water does not drain well. So the risk of flooding is high. Although this may pose a risk to the surrounding communities, it is a boon to researchers: The area has the ideal conditions in which to explore the factors that contribute to flooding. In the 1960s, WSL equipped various mountain torrents in the Alptal with measurement devices to find out how the forest affects the formation of floods and water quality. Researchers have also been looking into how sediment and driftwood are transported, among other issues, since the 1980s and have developed models for forecasting floods for several years.

Dieter Rickenmann, a researcher in the mountain torrents group, stands with two Japanese colleagues looking at the Erlenbach stream in Alptal. Despite the sun, it is cool, the air is damp and their fingers quickly become clammy. When they reach the large retention basin, Rickenmann shows his guests how WSL researches sediment transport in one of the most active mountain torrents in Switzerland. There is a reason the visitors have traveled so far: The WSL's sediment measurement equipment is not found anywhere else in the world.

WSL's hydrological work in Alptal: *www.wsl.ch/more/alptal-en*

When rock meets metal

WSL workers developed a method to monitor and measure the sediment indirectly. The geophone records the vibrations that sediment particles cause when they roll over steel plates. The steel plates are embedded in the streambed, with the geophone sensors mounted on their underside. The signals are calibrated using direct measurements of the transported sediment. To do this,

Photo: Alexander Beer, WSL

The sediment transported by the Erlenbach during flooding collects in the inlet basin. It is measured regularly and then dredged.

the researchers attached collecting baskets at the inlet of the retention basin. These baskets are mounted on horizontal rails and are pulled into the flow of water automatically by winches whenever the flow is strong. There, they collect sand, gravel, and cobbles transported along the stream bed. The material collected in the retention basin is also used to calibrate the measurements of the geophone, by measuring the deposited sediment.

"Using these measurements, we were able improve the calculation methods for sediment transport significantly and develop a computer simulation model. We can now use this model to calculate how much sediment will be transported under what conditions – even for longer stretches of mountain streams," explains Rickenmann. The model was used as part of National Research Program 61 'Sustainable Water Management'. Researchers looked at how climate change might affect sediment transport and the living conditions for the brown trout.

The collecting baskets remain motionless today, as there is hardly any water in the Erlenbach, let alone sediment transport. The fact that the mountain stream can look quite different is documented by the photos from the last major flood in June 2007. Following a rainstorm, the Erlenbach filled the inlet basin with stones, mud and driftwood in about two hours. "This sort of extreme event takes place here about every 10 years. We have about 15 to 20 floods with sediment transport annually," says Rickenmann. Fortunately, the stream did not cause any damage to the nearby hamlet of Brunni.

More information about WSL's large-scale experiments: *www.wsl.ch/more/lse*

First in the field, then in the lab

Planning, construction and maintenance of a system such as at the Erlenbach is expensive. The inlet basin must be dredged regularly to ensure that it can collect a good amount of sediment at all times, even in a major flood. The excavator loads some 1,000 cubic meters of material in 85 trucks, which then bring it to a waste disposal site. "The maintenance is intensive, especially for the flow measurements that we need to calculate the sediment transport. A staff member inspects the measurement data each week and cleans the dirty instruments," explains Rickenmann.

Perhaps in the future it will be possible to calibrate the geophones in the lab, which would be easier and cheaper. Doctoral student Carlos Wyss looked into this in his doctoral work at WSL. His results were encouraging, although the laboratory calibrated methods were not quite as precise as had been hoped.

Hot, dry Illgraben and wet, cool Erlenbach: The commonality in both of WSL's large-scale experimental facilities is that the experiments are triggered by nature, rather than man. Rickenmann explains: "We observe natural processes that absolutely could not be triggered artificially on this scale." *(gpe/lbo)*

Geophones attached to the underside of these steel plates record vibrations and measure transport of coarse sediment on a continuous basis. The three metal collecting baskets are drawn automatically one after the other into the heavy flow of water.

Photo: Lisa Bose, WSL; photo p. 8/9: Terre et Nature, Olivier Born

Ideally, the explosive charge is lowered from a helicopter and detonated on the snow surface. In high winds, the explosive can be thrown from the helicopter into the starting zone.

A lot has to go right to ensure that this rare experiment succeeds: snow volume, weather conditions, snow layering, temperature, clear visibility for the helicopter and measurement devices.

The SLF operates a unique test site for big avalanches in Valais. Radar and sensors measure the speed, pressure, density and temperature of the snow mass. The data help in the development of simulation models and programs.

Vallée de la Sionne, Arbaz (Valais).

ONE-TWO

From large-scale experiments to pop-up tests

Controlled triggering of avalanches, measurement of debris flows and rock caught in protective nets – what for? An interview with Perry Bartelt, WSL, and Lorenz Meier, Geopraevent, about large-scale experiments.

Lorenz Meier is the CEO of Geopraevent, which develops warning and monitoring systems for natural hazards. He worked at SLF from 2009 to 2013.

Perry Bartelt heads the 'Rapid Mass Movements RAMMS' program at WSL. The eponymous software models avalanches, rockfalls and debris flows.

What role have large-scale experiments played in your professional career?

PB: A major role. We started by observing; we made and watched videos of avalanches, debris flows and rockfalls to see what we could uncover. Now we look into selected aspects, such as powder clouds. We say, "We should see x, y and z in an avalanche" – and then we test it at the avalanche test site in Vallée de la Sionne (VdlS).

LM: I learned a lot about sensors at VdlS – and I still work with sensors today. Once, I was in the bunker at VdlS with the measurement devices, but the avalanche did not go off. That's one of the disadvantages of large-scale experiments: They're expensive and involve a lot of technology, but events are rare.

How often do you successfully trigger an avalanche in VdlS?

PB: A major avalanche, every two or three years.

LM: When they occur, avalanches provide a lot of very good data. But you have to be able to wait. It's a somewhat passive form of research. As a small start-up, we cannot afford to wait three years. We have to be able to bring our product to market quickly. So we go where something is happening, such as Brienz (Graubünden), where rockfalls regularly occur. We have a simplified measuring concept with just a few devices; in this case, a camera and a radar. This allows us to obtain data quickly.

PB: We also do not want to wait too long if there are specific questions. But in order to be able to develop a natural hazard simulation program at all, such as RAMMS, we need data from the large-scale experiments. Now we can quickly and flexibly collect data in field situations, such as Brienz, using small mobile tests – which we call pop-up tests – and thus check RAMMS at other sites.

How important are the findings of large-scale experiments to Geopraevent?

LM: They are indirectly important. For example, to ensure that we identify the correct path of an avalanche for an alarm system, our partners simulate where it will flow using a computer. The computer programs used for this are based on the findings from the large-scale experiments. And we can use large-scale experiments to test new technologies, such as radar, that we use later on. We are not able to develop completely new technologies ourselves.

WSL has stopped conducting large-scale experiments in recent years. Are pop-up tests the future?

PB: Rockfalls can be better investigated using field experiments;

Photos: Birgit Ottmer, WSL

A 19-meter measurement tower in the middle of an avalanche track in the Vallée de la Sionne. It has a number of measurement devices to check the speed, pressure, density and temperature of an avalanche.

Photo: Martin Hiller, SLF

More information about large-scale avalanche experiments is available at: *www.slf.ch/more/vdls-en*

A video on this topic can be viewed at: *www.slf.ch/more/film-avalanche*

for example, on grassland, in forests, on scree slopes and with various rock formations.

So large-scale experiments will be phased out?

PB: I think they will be for rockfalls, but not for avalanches. If the climate changes and there are more avalanches in the future, it will be good to have data from the VdlS.

LM: Another factor in favor of pop-up tests is that computers nowadays are much smaller and more powerful. It's no longer necessary to have an entire rack in a bunker. And with laser scans, you

can get an accurate terrain model in an hour. I don't think any new large-scale experiments will be performed at a fixed location.

PB: But there are still unresolved problems. For example, we get a lot of questions about ice and powder avalanches in the Himalayas. The enormous differences in altitude, the quick movements, the powder clouds that behave completely differently at 6,000 meters: in order to understand the physics, we use data from powder avalanches in VdlS. Or debris flows, which are much less common and more difficult to predict than avalanches. We are not as far with this research and, in particular, we still do not understand the mass balance. So we will still need large-scale debris flow experiments in Illgraben.

For more information about the RAMMS research program, please go to: *www.slf.ch/more/ramms-en*

Does this also correspond to your needs as practitioners?

LM: You focus on the basics. We want to be sure that people understand these as well. To that extent, it corresponds to our needs. But I have a provocative requirement: I think that RAMMS should be open source.

PB: But we do not have the resources to do this. The money that we earn with RAMMS goes directly into further development and user support; for example, through training.

LM: Then you have to sell the training programs! Or certifications: Those who want to use RAMMS must be trained by you. That way, you will have quality control to ensure that the models are used correctly and the results interpreted accurately.

Fifty years ago, 88 people working on the Mattmark dam were killed by a glacier avalanche. Could such a tragedy be avoided today through large-scale experiments?

PB: Nowadays, modeling would probably be used to determine where to place worker housing.
I would like to simulate it to be able to answer this question.

LM: You can see how we deal with unstable glaciers today by looking at Weissmies in Valais. In the summer of 2014, falling ice became more frequent as part of the glacier had become unstable.

Scientists and technicians monitor measurements in the observation bunker at the avalanche test site; radars measure the speed of avalanches.

Photo: Martin Hiller, SLF

Large-scale experiments are now supplemented with mobile systems. Here, a researcher measures an avalanche using a drone in order to later calculate the precise distribution of snow.

RAMMS simulations showed how much ice had to break off before it fell on to the slope or even down into the valley. Since then, we have been monitoring the glacier with radar. We can identify when larger chunks will break off a few days in advance based on the increased flow velocity. We can also estimate the size of the chunk that will break off. Then the authorities can take protective measures.

This would not have been possible 50 years ago?

LM: No, because the models were not available, in part because there was still no data from large-scale experiments, nor was the measurement technology as advanced.

PB: There was also a lack of terrain models and computing power at the time. But the main problem was that the processes were not understood well enough to be modeled – today, thanks to large-scale experiments, they can be. So the benefits of large-scale experiments for society are great. *(bio)*

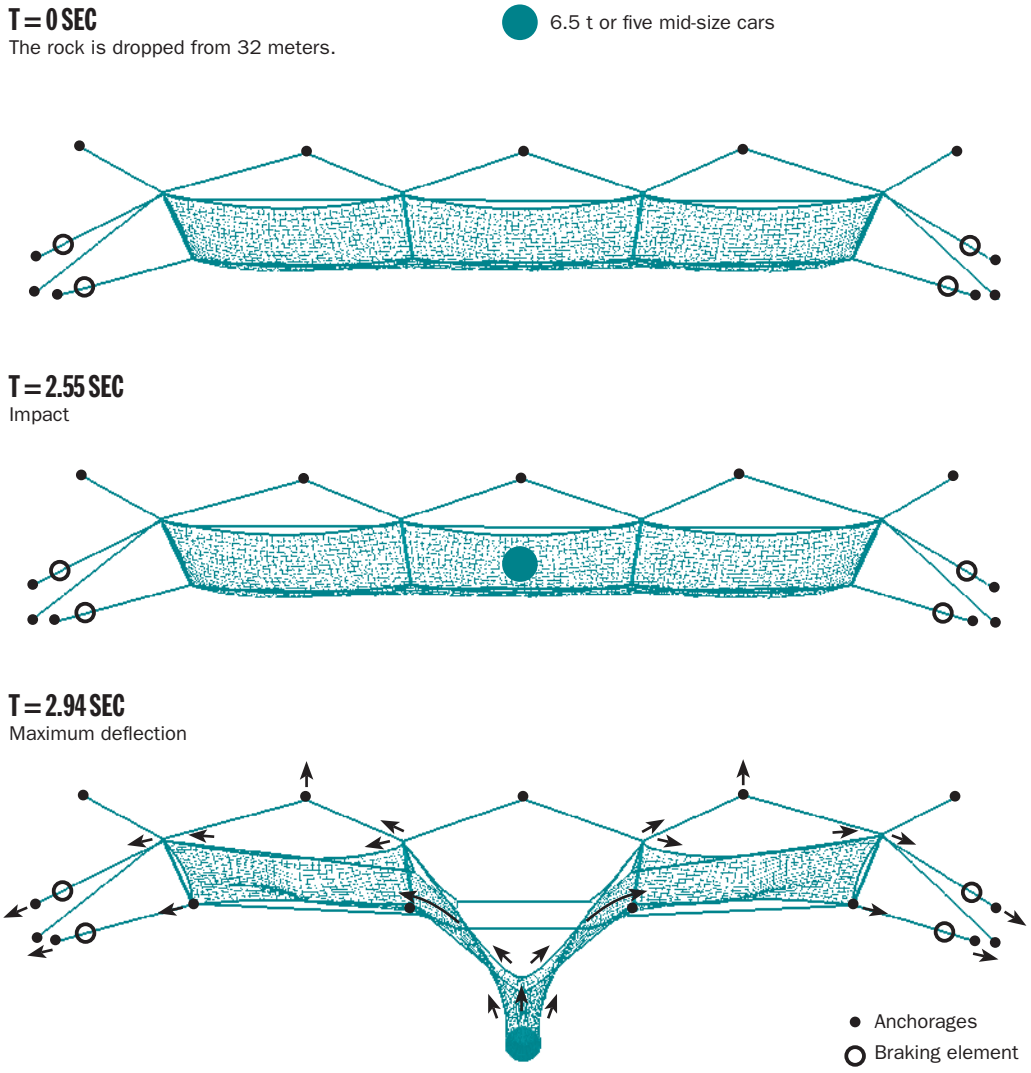
Photo: Julia Wessels, SLF

"I don't think any new large-scale experiments will be performed at a fixed location."

INFOGRAPHIC

Flexible rockfall protection systems

WSL tests protective rockfall nets at an old quarry in Walenstadt according to international guidelines. The key aspects are the loads on the anchorages, the stopping distance and the condition and height of the net.



WSL also develops computer models that simulate the costly field tests. Researchers face enormous challenges in this regard: How can the deceleration process of the rock, the deformation of the net and the maximum load on the anchorages be modeled, and how accurate are the simulations compared with reality?

BRAKING ELEMENTS at the cable ends absorb the energy of the impacting rock through plastic deformation at the moment of impact.

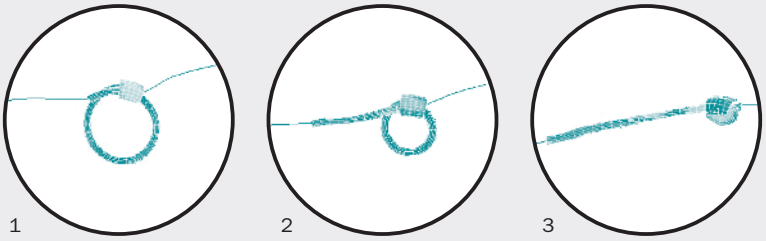


Illustration: Axel Volkwein, WSL/Raffinerie

TEST LAB IN THE CHESTNUT FOREST

Furniture instead of fuelwood

WSL is conducting a large-scale experiment in the Ticino forest. The goal is to find a management method that makes chestnut wood economically attractive again.

He was 45 years old when he planned the experiments in the Ticino chestnut forests. But he will no longer learn the results of this large-scale experiment, at least not as an employee of WSL. Andreas Zingg is about to retire. He has dedicated nearly all his professional life to growth and yield research, how forests and thus the volume and quality of wood change with different management systems. And yet he never intended to work at WSL: "When I was a student, there two things I definitely never wanted to do," says Zingg, who has a forestry degree from ETH, with a grin. "Make inventories and work at the research institute."

But he does not regret his time at WSL, even though a forest researcher requires a lot of patience. "Compared to a person, trees and forests grow very slowly. A problem that we look into today may no longer interest anyone later on when the results are available," says Zingg. He has to live with this risk. So it is all the more important that the results of the research can be used for other questions. Such as in Ticino, for example.

Earn more from chestnut wood

Since the time of the Romans, who brought the sweet chestnut to Ticino, this tree species has been enormously important for our southern-most canton. Chestnut forests now grow everywhere where there were originally lime and mixed oak forests, and the chestnut is the most important hardwood species on the southern side of the Alps. The people of Ticino have used their 'castagni' in a number of different ways over the centuries. They produced the fruit in their chestnut orchards, and for years it was their most important food product. In the coppices – forests that are cut down completely every 12 to 20 years – it is used for fuelwood or turned into vine stakes and fence posts. Those times are now past: as the coppices generate too little profit, the forest owners have hardly used them for the past 50 years and the chestnuts grow unimpeded.

Zingg and his colleagues have made it their goal to change this. Zingg: "What we hope to achieve with this large experiment is to make chestnut wood an attractive product again. We're testing innovative methods of management of the chestnut woods, so the timber can be used not only for heating, but also for furniture or flooring." Compared to a cubic meter of fuelwood, which currently costs about CHF 50, several times this amount can be earned from high-grade timber. If the coppices become attractive again for the forest owners, the chances that this important part of the landscape in Ticino will be maintained will increase as well.

A previous WSL study encouraged Zingg to carry out the Ticino field trials. Chestnut wood is comparable to oak in terms of quality. Unlike oak, however, chestnut tree suffers from 'ring shake', a defect that causes the wood to come loose along the growth rings as a result of strain or injuries. A board that has been affected by ring shake may fall apart or have holes in it. But not always. Zingg: "Patrick Fonti, a former doctoral student and current employee at WSL, learned that there tends to be no ring shake if the tree grows in a location with good access to water and nutrients, is able to form regular annual rings and is not more than 40 to 60 years old." As a result, Zingg set up three test sites in the 1990s, working with Marco Conedera and colleagues at the WSL field station in Bellinzona, as well as researchers from Arezzo in Italy. All three test sites are in the 'chestnut belt'. They differ mainly in terms of elevation, aspect, gradient and earlier management. One of these sites is in Bedano, a village in the Lugano region.

The test lab is almost as big as three football pitches

The area still produces large, beautiful 'Torcion négro' fruit – the best chestnut species in Ticino – and the test site was previously used as an orchard. However, this stock of pure chestnut trees has been used as a coppice for more than 50 years. As at the other two test sites, the two researchers use three types of silvicultural techniques in the forest, which is approximately two hectares large, with each technique repeated three times. Zingg: "We clear-felled the entire area in 1998. The stools of chestnut trees that have been cut always sprout again vigorously. On one part of the site, the control area, the trees have grown unhindered since then."

As part of the second management system, after eight years the researchers selected crop trees – trees that grow straight and form a regular crown. They released these trees from the most vigorous competitors and pruned them a year later to a height of six meters in order to create the best growing conditions for a good crown shape and to ensure the high quality of the lower trunk. They have since carried out this procedure once more.

Information about growth and yield research: *www.wsl.ch/more/yieldresearch*

Under the third management system, after eight years they left half of the dominant coppice shoots standing and cut the other half down. This management system has also since been repeated once. Since 1998, employees at the Bellinzona field station measured each tree annually on the two-hectare test site in accordance with a protocol that is used at all growth and yield research test sites. The metrics include position, tree species, diameter and height, and 'social position'. If, at the end of the experiment, it turns out that no one in Ticino is interested in chestnut wood, these data can be used to answer other questions, such as how chestnut forests develop with climate change.

The large-scale experiment is planned to take about 30 years. After that, the entire site will be completely clear-felled again according to the coppice management. But the initial trends are already apparent today, after just 17 years. Conedera: "To us, it seems best to develop the option with the crop trees." These trees have a considerable diameter of about 30 centimeters and far exceed the crowns of the other trees. This development stands in contrast to the practice in Italy. Conedera: "Some of our crop trees were grown from

Marco Conedera (left) and Andreas Zingg examine a crop tree – a chestnut tree that will provide furniture wood after the experiment.

Photo: Christine Huovinen, SLF

seed. So they're quite straight. In the drier, Mediterranean climate in Italy, the seeds only germinate and establish in exceptional years, so there it is better to rely on re-sprouts and thinning out half of them."

Despite these initial findings, few people in Ticino seem interested in implementing this new type of coppice management; to date, only one forester has been persuaded of the method. This is no surprise to Zingg: "Foresters

are generally somewhat conservative, and," he says with a wink, "their social psychology is an entire topic in itself."

Wood – an alternative to oil

WSL now has a total of 131 growth and yield research test sites in Swiss forests such as the one in Ticino, covering a total of some 130 hectares. Some of these sites have existed since 1886, the year the research institute was established. The years of data series are correspondingly valuable. Unlike the experiments in Ticino, most of these tests involve case studies. Zingg: "There have been very few experiments in growth and yield research to date that allow us to make a statistically representative statement. In the future, WSL will increasingly rely on such studies as in Ticino's chestnut forests." Just as the work with computer models, it will be possible to extrapolate the future value of wood under various site conditions and management methods. For Zingg it is clear: "With oil in increasingly short supply, wood, as a renewable resource, will become increasingly important. So it is all the more important to test and develop sustainable forestry processes in a timely manner." Zingg found the motivation for his many years of work as a result of this conviction. Nevertheless, he is looking forward to retirement and being able to enjoy the chestnut forests solely for their beauty. *(chu)*

Arthur Gessler, Birmensdorf

“At our LWF demo area in Birmensdorf, we carry out experiments and test new measuring systems. But it’s also a meeting place where we show our work to members of the public, particularly school classes, and give them a closer understanding of the forest.”

THE FOREST UNDER CONSTANT OBSERVATION

How do trees grow? What are the characteristics of soil? What effect do air pollution and climate change have on the forest? These are the questions Arthur Gessler investigates as leader of the long-term forest ecosystem research program (LWF). He enjoys exchanging ideas with other researchers, students and interested members of the public: “Science needs to be a dialog – it shouldn’t take place in a closed system.”

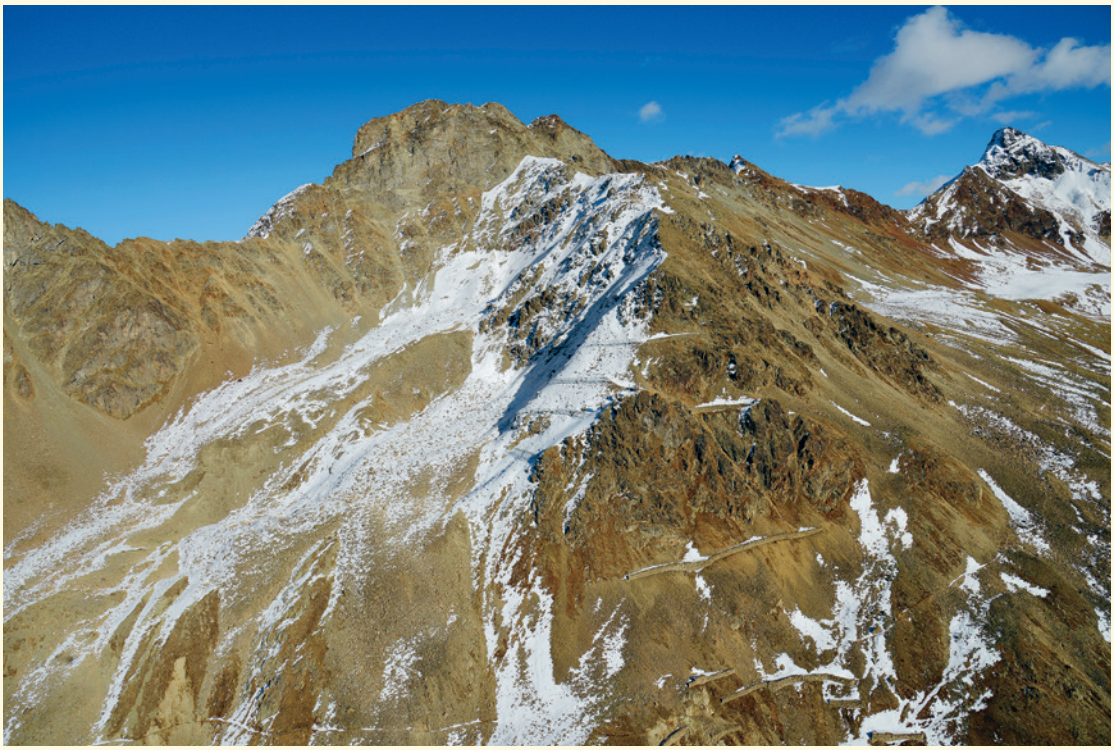
Photo: Bruno Augsburger, Zurich

The colder it gets, the more life you find: alpine permafrost is rich in micro-organisms

Muot da Barba Peider, a mountain peak beneath Piz Muragl in the Upper Engadine. At almost 3,000 meters above sea level, the average annual temperature here is –3 °C. The soil below a depth of 1.5 m is permanently frozen, as evidenced by SLF's long-term monitoring data. Surely, nothing can survive in this permafrost – or can it?

For the first time, soil samples from the alpine permafrost have been searched for life by WSL microbiologists Beat Frey and Martin Hartmann. The results are surprising: they found up to 1,000 different types of organisms, many of them unknown, or virtually unknown, until now. Furthermore, the diversity of bacteria, fungi and other micro-organisms is greater in the permafrost than in the thawed and active soil layer above. The two researchers have analyzed the permafrost microbiome and found that a large number of the organisms in the permafrost do not have known relatives. "We're cultivating some of them now in the lab to find out what they need to survive," explains Frey.

The unknown micro-organisms also have the potential to be harmful if the permafrost contains organisms detrimental to humans and animals. If the permafrost were to thaw, for example, these organisms would reach the valley via the meltwater and arrive at heavily populated areas. However, they are also interesting on a biotechnological level; for example, in the development of environmentally friendly chemicals. *(lbo)*



The soil samples from Muot da Barba Peider (first peak in the foreground) are full of life. Astonishingly, the researchers found more organisms on the colder north-east side of the ridge than on the south-west side.

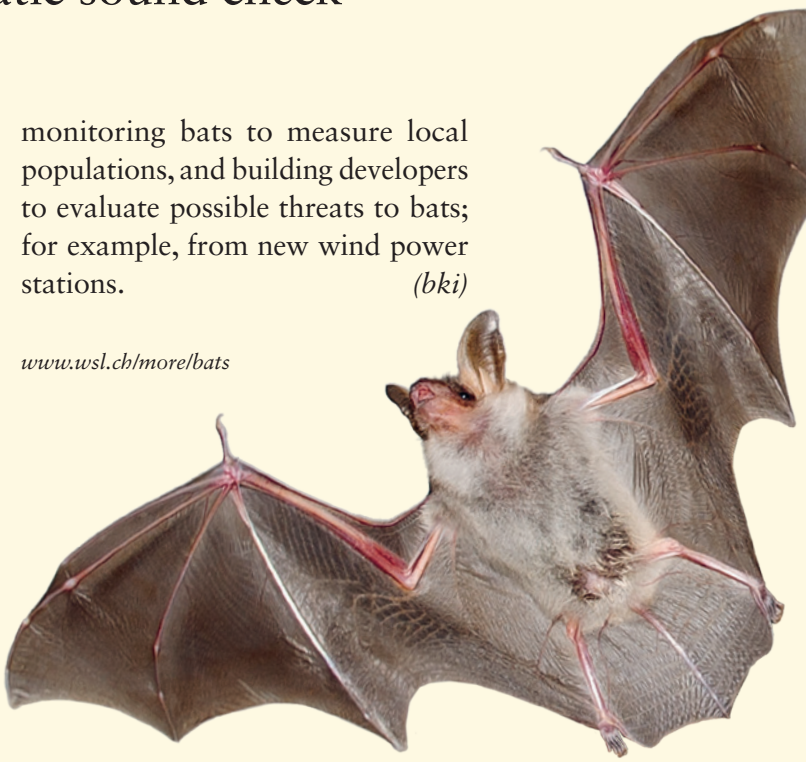
Photo: Marcia Phillips, SLF

BIODIVERSITY

An automatic sound check for bats

Identifying bats as they fly by in the darkness of the night – Batscope, the software developed by Ruedi Boesch and Martin Obrist at WSL, can do just that. It analyzes bat calls that have been recorded with special devices (Batloggers). The software breaks down the recordings into individual calls and classifies them to the most likely species, according to a reference database. "It's based on complex statistical modeling that yields very precise results," explains Martin Obrist. Obrist and his colleagues used the software to collect data on the bat population for Switzerland's Red List Chiroptera (bats), published in 2014. It could also help those responsible for monitoring bats to measure local populations, and building developers to evaluate possible threats to bats; for example, from new wind power stations. *(bki)*

www.wsl.ch/more/bats



The greater mouse-eared bat *(Myotis myotis)* is severely threatened by building renovations and attic conversions.

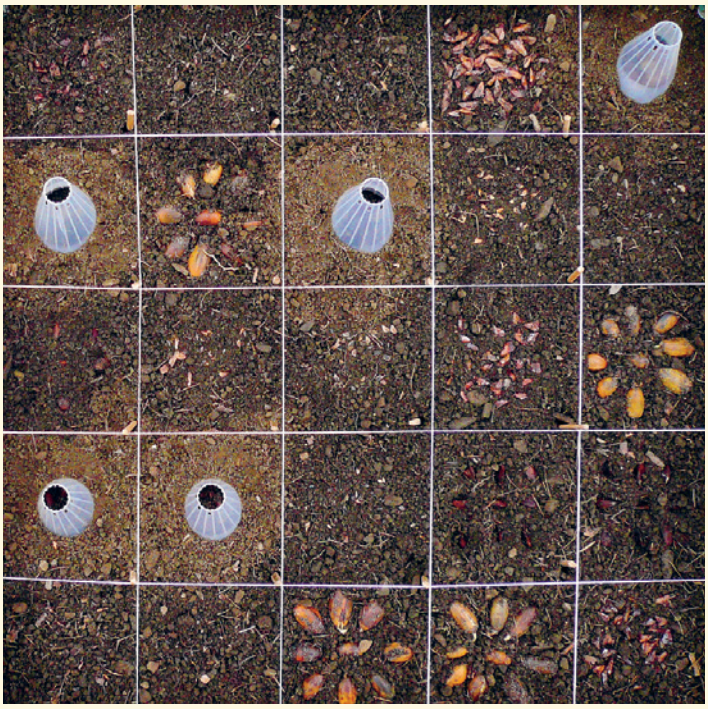
BIODIVERSITY

Use of genetic techniques to help protect endangered plants and animals

The wood grouse and the northern crested newt. Two very different animals with one common feature: both are rare in Switzerland and both are threatened with extinction. Determining if and how many individuals are living in a particular area by conventional methods means observing or even capturing the animals. Nowadays, however, their trail can be picked up without disturbing them through analysis of their genetic traces, whether that's wood grouse droppings or a water sample from a pond where a northern crested newt has been. Although genetic techniques open up new possibilities, they are often met with skepticism by conservationists. Naturschutzgenetik, published this spring by Haupt Verlag, aims to break down these barriers. It provides background information and case studies that demonstrate the value of genetic techniques in conservation. "With this book, we're hoping to link science together with practice," says Rolf Holderegger, WSL researcher and co-author of the work. *(lbo)*

Photo: FEBEX Haffner & Stutz

Indigenous Scots pines germinate better than those from southern and eastern Europe



Experimental plot with 25 sowing squares (10 × 10 cm). In the first year of the experiment, the researchers tested plastic cones as a growth aid.

Climate change is having a dramatic effect on pine forests in the low, south-facing regions of the Chur Rhine valley and in Domleschg. With a two-degree rise in the annual average temperature and the same level of precipitation as 50 years ago, Scots pines need more water than is available and are currently dying off. If the forest is to continue to carry out its various roles, young trees must replace the ones that are dying. A key challenge is to determine which locations still have a sufficient level of soil moisture for Scots pine seeds to germinate and for their fragile seedlings to grow.

Between 2009 and 2014, WSL carried out an experiment in collaboration with the Office for Forestry and Natural Hazards (Amt für Wald und Naturgefahren) in canton Graubünden, in which it tested the germination and development of Scots pines and spruce trees in the Rhine and Rhone valleys, as well as those from continental areas of eastern Europe and the Mediterranean region. "By focusing on germination, we wanted to find out whether seeds from dry areas were better suited to the future climate of the Rhine valley than native ones," says Barbara Moser from the Disturbance Ecology research group. The team sowed seeds on south-facing woodland areas with different soil characteristics situated less than 1000 meters above sea level, and altered the soil moisture using small roofs that provided varying degrees of shelter from rain.

Spring weather conditions are decisive

The most decisive factor in the successful germination of seeds and the development of seedlings was the spring weather conditions. In 2013, these were wet; not only did significantly more young trees survive than in the dry spring of 2011, but they also had five times as much biomass two growing seasons later. Dry summers decreased the growth and proportion of young trees germinated in a wet spring only slightly. With sufficient rainfall in spring, Swiss seedlings did better than those from other countries; however, in the dry conditions of 2011, all the seedlings grew slowly and produced very little biomass.

Barbara Moser draws two conclusions from the experiment: With occasional damp springs and disturbances that bring light into the

Photo: Barbara Moser, WSL

forest, native Scots pines should rejuvenate regularly, even in very sunny areas, and help to ensure the continued survival of these forests. Scots pine regeneration is threatened only in soils that retain very little water. With consistent spring rain, Scots pines from already dry regions of eastern and southern European regions are unlikely to represent an alternative to native pines. However, should it become so warm by the end of the 21st century that almost every spring is dry, Moser recommends that other species are tested. *(rlä)*

www.wsl.ch/more/grisonsforests

FORESTS Historic water channels as a long-term irrigation experiment

On the south and south-east slopes of the Rhine valley between Lens and Varen in Valais, conditions are extremely dry. Vegetation is sparse and the trees are small – some have even died off. But not along the historic irrigation, or bisses, channels. For more than 500 years, these have channeled water into fields and meadows, with some of this water trickling off along the way – something the trees near the channels have used to their advantage.

While working on her doctoral thesis, Linda Feichtinger discovered that Scots pines along the irrigation channels that only recently started channeling water again after a long period of inactivity were growing better than those along permanently active channels. The fresh influx of water helped break down deposits of plant litter that had gradually built up, and the trees suddenly had access to additional nutrients. Experiments of this nature provide a unique opportunity to investigate how trees grow with different water supplies, and offer valuable prognoses as to how forests will develop in a changing climate. *(rlä)*

Photo: Linda Feichtinger, WSL

On the southern slope of the Rhine valley, Scots pines benefit from the water that seeps from the Grand Bisse de Lens.

Better structured forests mean fewer landslides

Landslides can break out in large forest gaps, such as this one in St. Antönien (GR).

Forests fundamentally stabilize the soil beneath them. In forests with significant gaps, however, a considerable number of shallow landslides have been observed. Terrain, geology and soil characteristics are known to influence whether such landslides take place. In her Master's thesis at SLF, Christine Moos investigated to what extent forest structure might also be responsible. ETH awarded her work the prize for its Master's degree program in Environmental Sciences.

In her research, Moos used data from laser scans and carried out field investigations in St. Antönien (GR). In the course of these, it emerged that the danger of landslides was smaller where trees were grouped more closely together, and where forest gaps in the direction of the slope measured less than 20 meters. The experiment also demonstrated that the direct field recordings yielded more reliable evidence than the remote sensing data. In a complementary bachelor's thesis, Josias Mattli examined to what extent roots with a spatial dependency on neighboring tree trunks reinforced the soil. Both studies allow a better quantification of how strongly the forest stabilizes the soil and protects against shallow landslides. *(mhe)*

www.slf.ch/more/sostanah-en

Photo: Christian Rickli, WSL

A unique environmental archive: ancient wood stored in Swiss soil

In May 2013, researchers from WSL made a sensational discovery in the Zurich Binz district: more than 250 Scots pine stumps of up to 14,000 years in age. There is reason to hope that the ancient wood might help to expand the current tree-ring chronology by about 1,500 years, bringing it back to the end of the last Ice Age, about 15,000 years ago. This would provide further insight into the climate history of Central Europe. Each tree ring may contain useful information about the temperature and precipitation at the time of its formation. WSL doctoral student Frederick Reinig, who is working with the Binz wood, gives an update on progress of the work: "It seems that some of the data necessary to finally complete the chronology are currently still missing."

New finds required

For this reason, the WSL researchers are still searching for new discoveries of wood that might be hidden in the ground, preserved in meter-thick layers of clay since the end of the last Ice Age. "Every tree counts," Reinig says. Even small finds could be of great importance if they help to fill gaps in the existing chronology. The ring widths of subfossil trees found in construction sites or gravel pits are measured and anatomically analyzed at the WSL. In a best-case scenario, it might even be possible to extract ancient DNA from these samples. The researchers, who are collaborating with research institutes in Potsdam, Freiburg i. Br., Hohenheim and Mannheim, would be extremely grateful for information on new finds. Their sampling efforts do not affect the progress of any construction work.

The first finds have already been reported: together with forestry services and construction companies, the researchers were able to excavate about 150 samples of pine, spruce and oak from Celerina (GR), Engi (GL) and Aigle (VD) in 2015. ^{14}C measurements at ETH Zurich's Laboratory for Ion Beam Physics show that the samples are up to 9,000 years old – although several older ones are still required. *(rlä)*

www.wsl.ch/more/subfossilwood

Extraction of wood discs from ancient oaks that had been preserved for several thousand years in lake sediment at a gravel pit in Aigle.

Photo: Frederick Reinig, WSL

River and stream renaturalization as seen by the media

The authorities should provide a range of information about the advantages and disadvantages of renaturalization.

About 15,000 km of rivers and streams in Switzerland are heavily overdeveloped. Since 2011, the Water Protection Act has obligated cantons to ecologically upgrade parts of these waters; for example, by creating habitats for plant and animal species typical to the area. It is also hoped that wider riverbeds will help reduce the potential damage caused by flooding. Despite these positive developments, renaturalization can be controversial, since, inter alia, it often requires the use of cultivated land and restricts the use of stretches of water for activities such as energy production. Participatory procedures, in which affected parties can put forward their point of view, can help resolve resource conflicts as amicably as possible. Since relatively few people participate actively in this process, the general public tends to form its opinion predominantly from press reports. Thus, the manner in which the media presents the restoration of rivers and streams plays an important role in a number of public objectives.

Public requires regular and in-depth information

In order to gain a better understanding how the media reports on naturalization, WSL researchers systematically assessed about 700 articles published between 2000 and 2013 in three newspapers in the cantons of Bern and Valais. They investigated, among other factors, which stakeholders voiced opinions and the arguments put forward. “Coverage is characterized by surprisingly favorable arguments,” explains Helena Zemp, who was responsible for the evaluation. A

Photo: Markus Forte/Ex-Press/BAFU

possible reason for this could be that critical points of view do not reach the journalists. Furthermore, says Zemp, the arguments relayed by the press were for the most part little differentiated and gave no grounds for the conclusions. Finally, some topics were scarcely analyzed in any of the three newspapers; for example, how the measures affected agriculture or the use of hydropower. In a recently published WSL report, the authors therefore recommend that project leaders inform the public about topics neglected by the media through means of panel discussions and newsletters. "More background information," says Zemp, "would allow the general public to come to a more informed opinion on the planned renaturalization projects." *(mhe)*

www.wsl.ch/more/mediaanalysis

LANDSCAPES

A history of the Swiss landscape: a look back offers ideas for the future

Mountains, lakes, picturesque villages: think of the Swiss landscape and these are the pictures that spring to mind. But do these pictures hold true – or, rather, do they still hold true? The landscape around us is changing constantly. Just as 15,000 years ago the landscape was molded by glaciers and weathering processes, now these formative interventions are being made by man. Today, the Swiss landscape is required to meet a diverse range of societal needs in a relatively small space. A look back at history can help instill some order into the changes happening today, and offer ideas for careful management of the landscape. It is with this in mind that Geschichte der Landschaft in der Schweiz (A history of the Swiss landscape) is published this spring. As Matthias Bürgi, landscape researcher at WSL and co-author of the book, explains: "Switzerland is, in a very real sense, a landscape laboratory. You'll find almost all the landscape themes here that are discussed in other European countries." *(lbo)*

www.wsl.ch/more/landscapehistory

Photo: Orell Füssli Verlag AG

How effective is avalanche blasting? Scientists blow the lid

Ten seconds left until the charge detonates. Stephan Simioni takes shelter. A deafening explosion fills the wintry valley of Hinterrhein, not far from the A13, where tourists are heading south in search of warmer climes.

Stephan Simioni prepares an explosive charge in Hinterrhein.

To protect ski slopes, and roads such as the A13, safety officers will often trigger avalanches with explosives as a precautionary measure. In his doctoral thesis, Simioni is investigating what happens during these explosions in the snow and the effectiveness of the blast methods. Today he's using video cameras to track if and where snow fails after an explosion. Microphones record how the waves caused by an explosion spread out across the snow, and acceleration sensors measure the extent to which the snow cover is deformed by the pressure. Since Simioni is carrying out his detonation experiment on level ground at a shooting range, it poses no danger to anyone. He completed his first blasting course – just for fun – while he was studying civil engineering. At the time, he did not know that it would soon become a passion.

Explosives or gas – which works better?

Since then, he has detonated somewhere in the region of 100 explosive charges; it is the largest series of experiments conducted by someone other than an explosives manufacturer, and the only one to compare different methods independently. And the work is not yet concluded; further experiments are planned, not just on level ground, but also on avalanche-prone slopes. Simioni would like to better compare the effect of systems that use explosives with those that use gas – a particularly useful planning aid for practitioners. That's why experts from various different cantons and ski regions are accompanying him in his doctoral work. The Federal Office for the Environment also sets great store by reliable results: Simioni's mission, therefore, is to present a standard test for the comparison of blast methods.

This work has already produced its first results: his experiments show that the stress caused by the explosion on areas within a certain distance of the blast is smaller than previously thought. To assess the practical implications of this, Simioni is working on a computer model that is able to simulate how simple topography, such as depressions or the slope angle, can influence the effec-

Photo: Jürg Schweizer, SLF

tiveness of the blast. He is also happy with the experimental set up at Hinterrhein: "The experiments on the level study plot and explosions on operational avalanche release systems are comparable. We are not far from a reliable standard procedure. The results of this work will give safety officers a valuable basis on which to assess where and how best to carry out avalanche blasting." *(chu)*

www.slf.ch/more/blastexperiments

NATURAL HAZARDS

A new assessment system for winter tours in the Jura

View from the Röti in Weissensteinzug (SO) towards the Swiss plateau. Avalanche terrain classification is particularly useful in the Jura, as the avalanche report there is available only from level 3 (considerable danger).

Photo: Archiv topo.verlag, Basel

Daniel Silbernagel, mountain guide and owner of the publishing house topo.verlag, was looking for a method to determine the risk of avalanches across the terrain of the Swiss Jura. Together with Christine Pielmeier of the SLF's avalanche warning service, he developed and tested a classification system that has already been successfully employed in a similar form in Canada. The system divides ski, snowshoe and hiking tours into three classes of terrain: easy, variable (partly challenging), and complex. The benefits of this work will be channeled into a number of areas, including Silbernagel's tour guides. New editions will be published in 2016, featuring 60 tours classified according to the system, which should make route planning a little easier for newcomers. *(chu)*

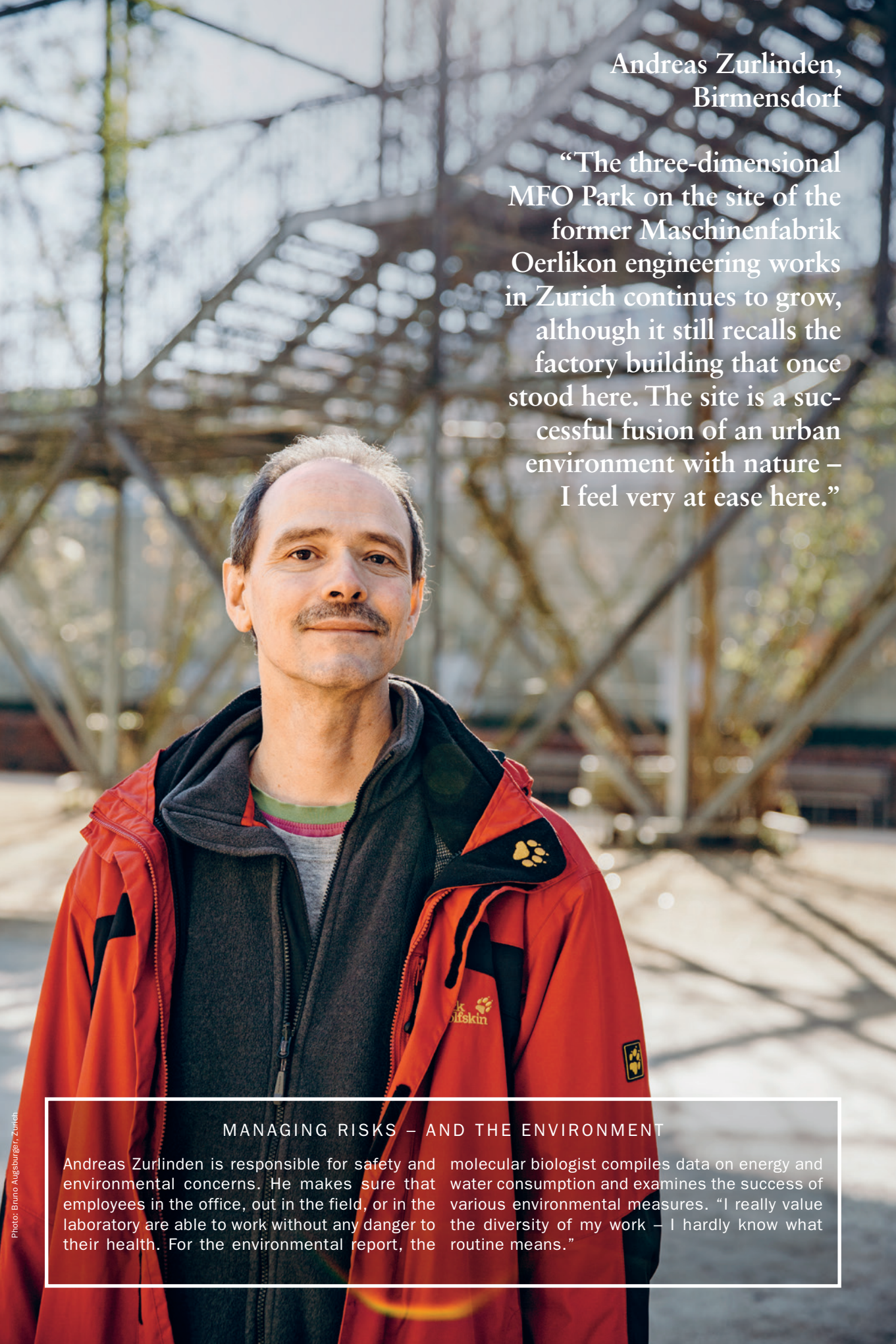
Improving community resilience to natural hazards

Badia in Italy is regularly affected by debris flows. A network of professionals and volunteers provide emergency relief to the community after a natural disaster (December 2012).

How well can a community recover from a natural disaster? According to the results of the European emBRACE (Building Resilience Among Communities in Europe) research project, alongside the size and nature of the disaster, a number of other factors come into play; for example, the personal, financial or natural resources a municipality can call on, how it acts in emergency situations, and how it learns from and adapts to these. The 11 research partners, including WSL, identified through case studies and surveys a series of key factors that can determine how resilient a municipality is against a natural hazard. Factors include whether an early-warning system is in place, how well informed the population is about natural disasters, the strength of their confidence in the authorities, and how well developed social networks within the community are. The project's findings are available for policy-makers in a handbook, enabling them to be better prepared in future against debris flows, avalanches, floods, heat waves and earthquakes. *(chu)*

www.wsl.ch/more/emBRACE-en

Photo: Christian Iasio, Italy



Andreas Zurlinden, Birmensdorf

“The three-dimensional MFO Park on the site of the former Maschinenfabrik Oerlikon engineering works in Zurich continues to grow, although it still recalls the factory building that once stood here. The site is a successful fusion of an urban environment with nature – I feel very at ease here.”

MANAGING RISKS – AND THE ENVIRONMENT

Andreas Zurlinden is responsible for safety and environmental concerns. He makes sure that employees in the office, out in the field, or in the laboratory are able to work without any danger to their health. For the environmental report, the molecular biologist compiles data on energy and water consumption and examines the success of various environmental measures. “I really value the diversity of my work – I hardly know what routine means.”

Photo: Bruno Augsburger, Zurich

Forest structure influences snow distribution

A large share of global freshwater run-off originates from forested areas that are covered in snow during winter. When and how fast this snow melts can influence whether floods occur. It is just as important to determine how much snow is in these forests and how much of it reaches bodies of water during thawing. The thickness of the snow cover in non-forested areas next to these forests is a poor indication of this, as the treetops in a forest can retain up to half the snowfall. A significant proportion of the snow is absorbed directly from the trees back into the air as water vapor, and therefore does not contribute to local run-off generation. Previous models, which aimed to simulate the development of snow cover in forested areas, were oversimplified and provided an inadequate interpretation of the variability of snow cover below trees.

Treetops retain a significant proportion of snow. From there, it either evaporates or later falls to the ground.

Photo: Tobias Jonas, SLF

Improved model considers forest structure

In his doctoral work at SLF, David Moeser used laser scanning data to detail the distribution and size of gaps in the canopy. At the same time, researchers from the Snow Hydrology research group at SLF took more than 84,000 snow measurements across nine test sites in the area around Davos over three snow seasons. It is the most comprehensive field study of forest snow distribution in the world. The combination of snow measurements and laser scanning data enabled Moeser to develop a snow model that can accurately predict the amount and spatial distribution of snow, even in irregular forest structures. *(mhe)*

www.slf.ch/more/foreststructure

Snow accumulates even on steep rock walls, influencing rock temperature

Anna Haberkorn climbs a rock wall on the Jungfraujoch to dig a snow pit.

Photo: Marcia Phillips, SLF

"Fieldwork is very important to understand nature," believes Anna Haberkorn. Indeed, it forms a central part of her dissertation. The meteorologist is investigating snow cover on rock walls, where it was previously assumed very little snow would accumulate, due to its tendency to slide off. This is wrong, according to Haberkorn: "My investigations show that snow cover between one and two meters thick can form on rock walls, piling up on ledges." It is an unusual kind of snow cover, with a conspicuous number of melt crusts and weakly bonded layers, and there is very often a basal ice layer. "The ice prevents meltwater from penetrating into the rock and bringing warmth into it," explains Haberkorn. This fact and the snow cover itself, which has an insulating effect and alters heat exchange, have an important influence on the thermal regime of rock – which, in turn, influences its stability. Using meteorological data and terrain-based information, Haberkorn can simulate the snow cover and rock temperature at individual points using the SNOWPACK computer model. She would now like to carry out such simulations for entire rock walls, and perhaps even for a whole mountain. A little office work is now on the agenda for this passionate mountaineer. *(bio)*

www.slf.ch/more/rockfaces

Bettina Richter, Davos

"I like to spend my lunch break at Pischa. You can get up there quickly with the cablecar. I especially like the view over the wild Vereina valley. After a nice descent, you can ski all the way back to the SLF on the Flüelapassstrasse."

COMPUTING SNOW STABILITY

Meteorologist Bettina Richter uses a model to simulate snow stratigraphy for her dissertation. The model will help to better assess the avalanche risk in the region of Davos. She uses data from weather-prediction models and automatic weather stations as input for her computer model: "I hope that through numerical avalanche forecasting, the avalanche warning experts will obtain more information for their daily forecasts."

Photo: Bruno Augsburger, Zurich

Risks and opportunities of energy transition

A future without nuclear power and less greenhouse gases: the energy transition promises a more sustainable future. But can Switzerland meet its needs with alternative energy sources? And will their development bring about unwanted side-effects for both man and nature? WSL's Energy Change Impact research program sets out to answer these questions.

Photos: Reinhard Lässig, WSL; Thomas Reich, WSL

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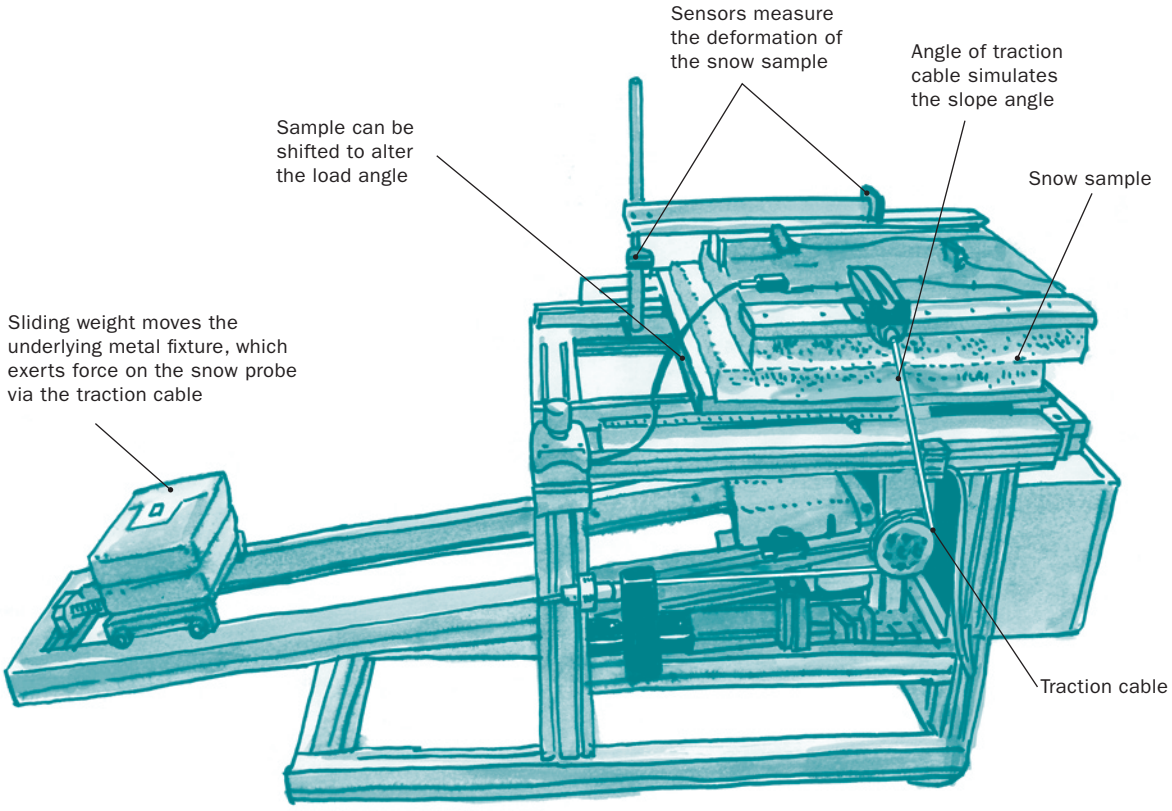
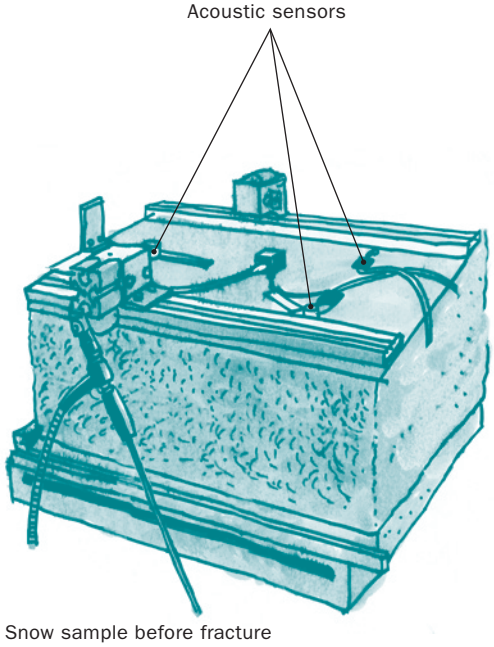
PEOPLE

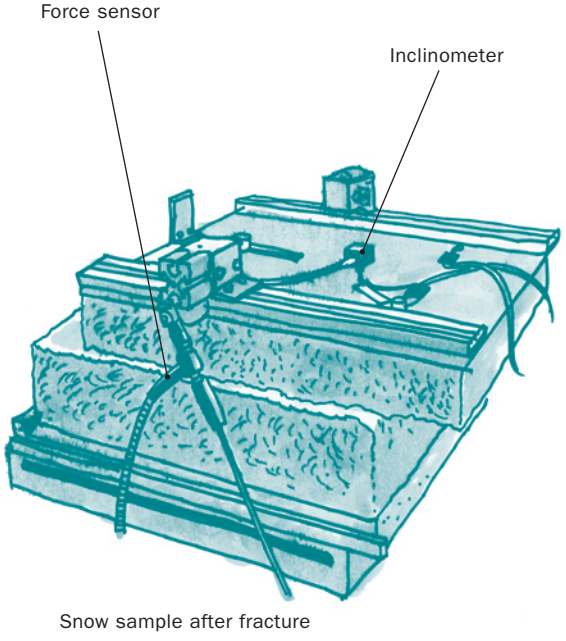
The WSL editorial team, from left to right, top row: Birgit Ottmer, Sandra Gurzeler, Reinhard Lässig, Beate Kittl; bottom row: Christine Huovinen, Lisa Bose, Martin Heggli

SHEAR APPARATUS





Snow sample before fracture



Snow sample after fracture

Before a slab avalanche occurs, small cracks and friction between the snow grains generate noise. The shear apparatus allows researchers in the lab to investigate the fracture process and the acoustic signals.

Video at:
www.wsl.ch/ding

Design: Raffinerie; cover: Ulrich Wasem, WSL

Snow on rock walls: temperature regime plays an important role, p. 33

Pine regeneration: at risk only in very dry environments, p. 22

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RESE ARCH 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 the use and protection of natural spaces and cultural landscapes. It monitors the condition and development of the landscapes, forests, 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, Bellinzona, Lausanne, Sion and Davos (WSL Institute for Snow and Avalanche Research SLF). It is a Swiss federal research center and part of the ETH Domain. You can find WSL's annual report at: www.wsl.ch/more/annualreport.

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