

# DIAGONAL

FOCUS

## No more nuclear: what are the next steps?

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## EDITORIAL

Dear readers,

The fact that WSL is conducting energy research may come as a surprise to some people. Developing technology, after all, is not our business. Nonetheless, all technology has an effect on the environment and society, be it positive or negative. Our researchers are thus investigating the risks and opportunities of the energy transition in Switzerland. After all, the people who decide which technologies to use should be aware of the potential consequences.

With an enormous project such as the energy transition, it is worth casting a glance into the future, and this is precisely what WSL and Eawag are doing with the Energy Change Impact research program. We are evaluating, for example, the energy potential of renewable resources in Switzerland, and exploring the effects of their use on species diversity, natural habitats and people. The intention is not to hinder the energy transition, but rather to discern the risks and opportunities in advance and to allow the best possible redesign of the energy system.

We hope you enjoy reading this issue.



Christoph Hegg  
deputy director, WSL



# Energy transition



## ONE-TWO

Rolf Iten, Managing Partner of the consulting firm Infrac: "We don't yet know how to integrate the energy transition into society and the economy."

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## BIOMASS FOR THE SWISS ENERGY TRANSITION

WSL is researching the energy potential of both woody and non-woody biomass.

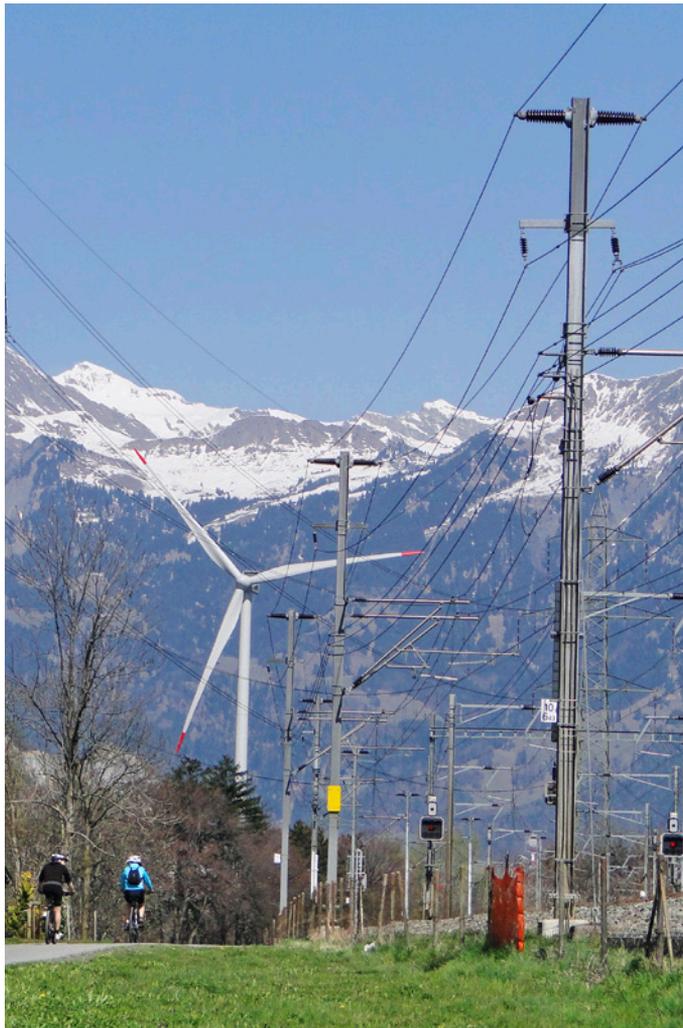
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## RENEWABLE ENERGY FOR THE FUTURE

Generating wind and solar energy requires a lot of space. While there may be conflicts involved, there are also plenty of opportunities.

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## WHAT KIND OF ENERGY TRANSITION DO WE WANT?

In order to phase out nuclear power, Switzerland will need to completely revamp its energy system. The WSL is researching the opportunities and risks associated with this long-term project.

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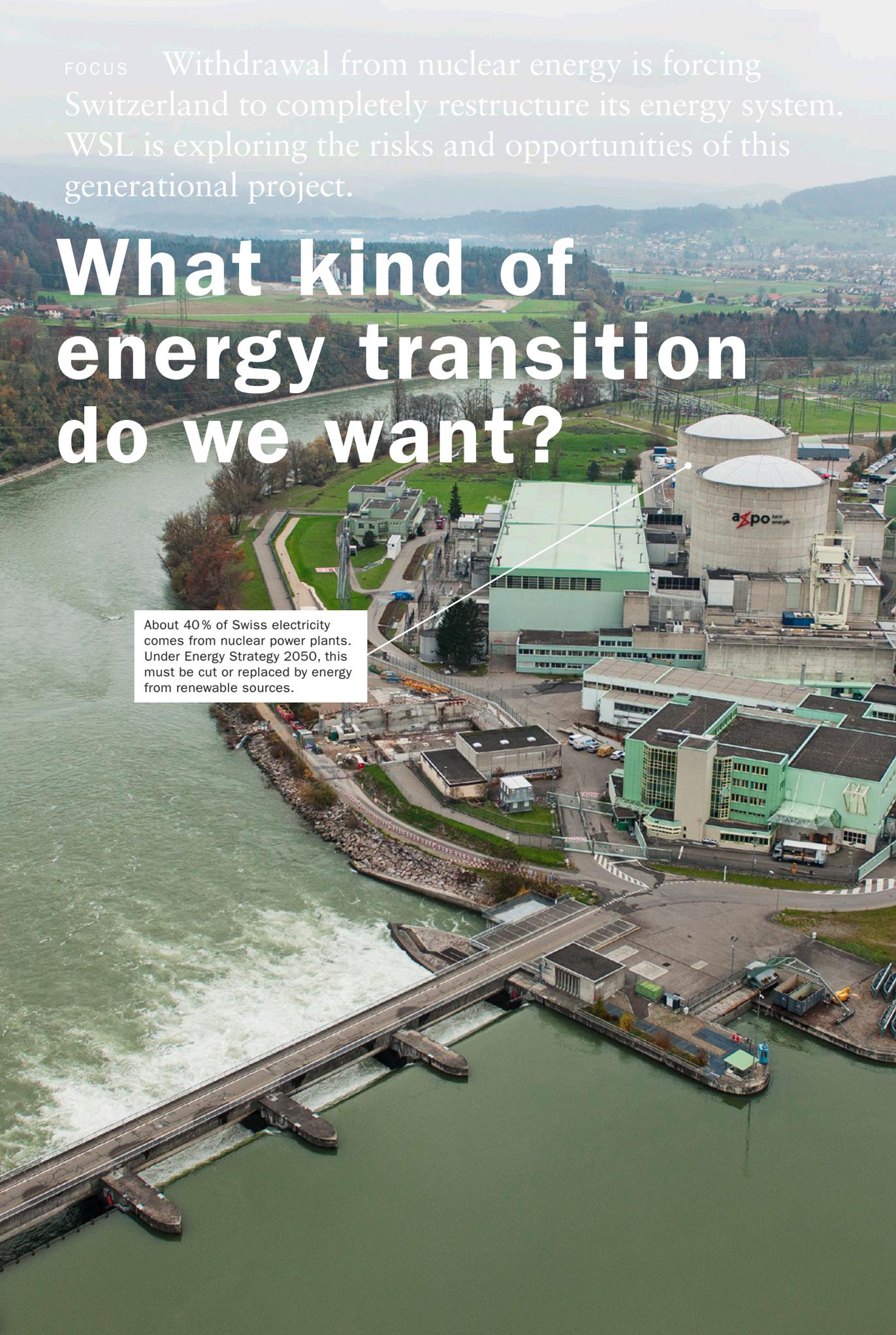
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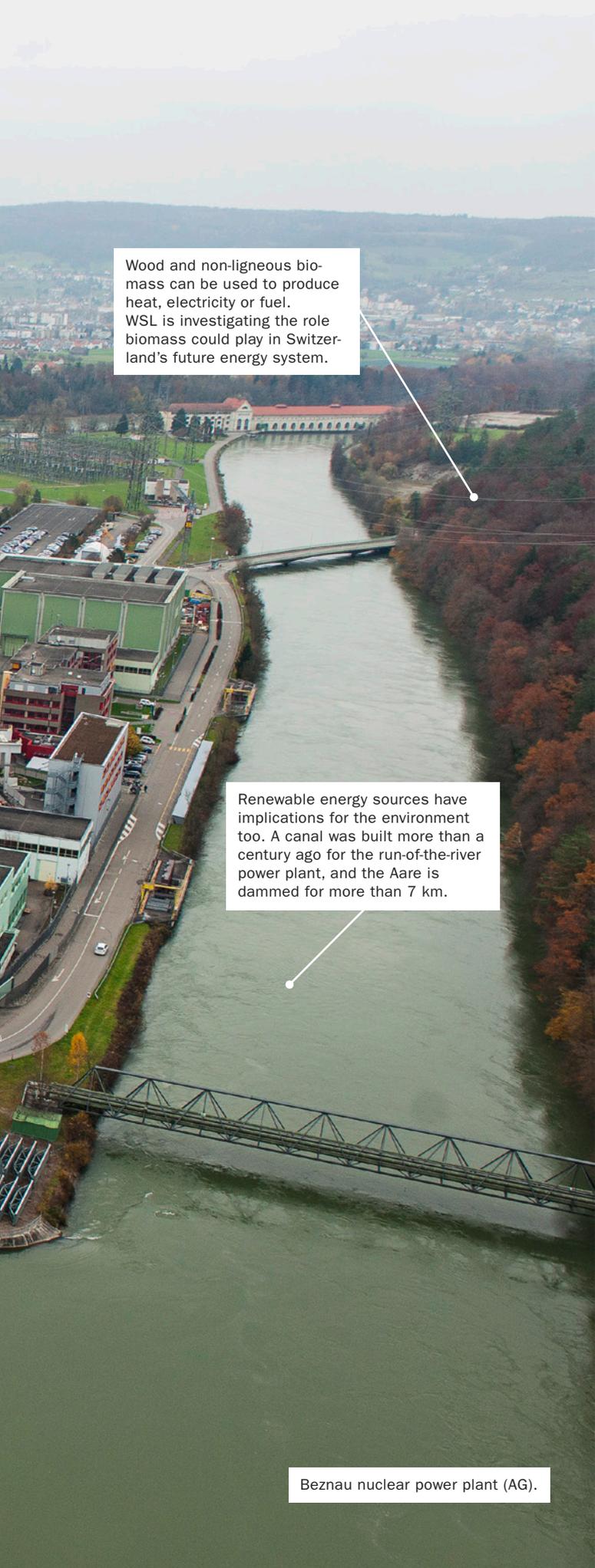
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FOCUS Withdrawal from nuclear energy is forcing Switzerland to completely restructure its energy system. WSL is exploring the risks and opportunities of this generational project.

# What kind of energy transition do we want?

About 40% of Swiss electricity comes from nuclear power plants. Under Energy Strategy 2050, this must be cut or replaced by energy from renewable sources.





Wood and non-ligneous biomass can be used to produce heat, electricity or fuel. WSL is investigating the role biomass could play in Switzerland's future energy system.

Renewable energy sources have implications for the environment too. A canal was built more than a century ago for the run-of-the-river power plant, and the Aare is dammed for more than 7 km.

Beznau nuclear power plant (AG).

In the aftermath of the Fukushima disaster, everything started to move very quickly: the Swiss Federal Council put together its Energy Strategy 2050, which committed to a withdrawal from nuclear energy, and parliament gave the move its blessing. Together, the five nuclear power plants in Switzerland produce roughly 26 terawatt hours (TWh) of electricity per year, which accounts for about 40 % of Swiss electricity production. The Federal Council aims to fill the gap through savings and the use of alternative – particularly non-fossil fuel – energy sources. To attain this goal by 2050, around 110 km<sup>2</sup> of photovoltaic systems will need to be built (equivalent to two thirds of the surface area of Liechtenstein), as well as 1,000 new wind turbines and at least a dozen geothermal plants. It is a project that will span generations.

### **Very little research on the impacts**

The government has recognized that a better understanding of the situation is required if energy change is to be successful. To remedy this, it invested around CHF 250 million in energy research between 2013 and 2016. Seven competence centers, two National Research Programs (NRP 70 and 71) and 24 Swiss National Science Foundation professorships have been investigating new technologies and the restructuring of the electricity grid, as well as looking into economic and legal questions. WSL researchers are participating in three competence centers and the National Research Programs.

With such a considerable endeavor, it makes sense to review the potential risks and conflicts that might arise from energy transfer, and to determine whether wood, wind,



Energy of the future, or wasted land and a blight on the landscape? Opinions differ on wind and solar power plants – including the oldest solar energy plant in Europe, which was built on an alpine field on Mont-Soleil (Canton Bern).

sun and water resources are actually sufficient. To this end, WSL and Eawag launched the Energy Change Impact research program in 2014. The ETH Board granted it CHF 1.5 million from the energy research budget in the period up to 2016.

### **Making informed decisions**

The goal of the program is to show the public, government and business the conditions under which the energy system will be restructured. Various WSL projects will investigate the potential of alternative energy sources. But with global warming in mind, will there be enough water to supply the new hydroelectric power stations? What sort of timber reserves can our forests offer in different cultivation scenarios? Other projects are examining the positive and negative effects of the technology on the environment, economy, and society. Regional economic locations, for example, benefit from wood production, but biodiversity might suffer depending on the kind of cultivation used. Or, if it is used wisely, it could even increase.

“The decision on which technology to use should be made in the knowledge of the implications for society and the environment,” stresses Christoph Hegg, Deputy Director of WSL. “Very few of the projects supported by government funds have this focus”, he notes. The Energy Change Impact program is a step in the right direction. In any case, the additional financing will run out in 2017, at which point WSL will have to finance its projects entirely from its own budget or acquire external funding elsewhere. And yet, it is precisely impact research that would allow to act preventively and to minimize risks. The Energy Change Impact program offers politics and society a small window into the future and opens up potential roads towards energy transition that will enable them to go in the direction they want, well informed.

*(bki)*

More information on the Energy Change Impact program: [www.wsl.ch/more/energychange-impact-en](http://www.wsl.ch/more/energychange-impact-en)

## ONE-TWO Energy transition as a trigger for collaboration. A great deal of research is being done on energy transition, but when it comes to transferring this into politics, industry and society, a number of questions still remain unanswered. A conversation between Astrid Bjørnsen (WSL) and Rolf Iten (Infras).

Both of you deal with the possible ramifications of the energy transition in your work. Where are the biggest gaps in our knowledge?

**RI:** When you undertake such a significant change on a political, technical and industrial level, you need a wealth of information. First, you need information on technology and resources, but you also need to know if it's acceptable for society and manageable for industry. The biggest challenge, in my opinion, is that we still do not know how to go about introducing the energy transition into society and industry.

**AB:** The challenge is to obtain an overall view of things, and to then deduce the best measures for implementing the energy transition right down to the local level – for example, how many wind turbines could reasonably be installed in a particular valley. That's an issue we have not yet resolved.

How do we get information to where it's needed?

**RI:** It seems to me that energy research nowadays is more academic than applied. As a result, questions that are interesting on a scientific level are often more important to professors and doctoral students than questions that arise from society, industry or politics.

**AB:** Despite this, there is an increasing awareness within the research community of the so-called Valley of Death; that is, the gap between research and marketplace. Research programs such as the European Horizon 2020 Framework Program and the Swiss Competence Centers for Energy Research (SCCER) provide more and more incentives to close this gap.

**RI:** For me, the Valley of Death is not so much about pure technology transfer as it is about transfer in politics and society. It's at this level that we're doing too little. I think the Energy Trialogue – a top-level discussion forum for scientists, businesses, politicians, consumers, and NGOs – is going in the right direction.

**AB:** The reason for the communication deficit in research lies in the academic system itself. What really matters in a researcher's career is publication. Time spent networking with politicians or seeking dialogue with the population – i.e. transmission of knowledge – is not valued highly enough. On the other hand, it's still very difficult to get non-scientists to attend energy research conferences, since this type of event does not suit the busy schedules of politicians and journalists. Researchers need a new con-



Rolf Iten (RI) is an economist, and managing director and partner at consultancy firm Infras, where he is in charge of the economic policy and energy departments.



Astrid Bjørnsen (AB) is an environmental scientist and heads the Energy Change Impact research program at WSL and Eawag.

ception of their role. We need more people able to deliver knowledge to both politicians and the general public.

**A great deal of research and discussion is going on, but not much is being implemented. Why?**

**RI:** After more than 20 years in business, I still don't know how to untie this Gordian knot. We know what is possible when it comes to technology and resources. We know that the energy transition is socially and economically feasible, but this message is not getting across. The moment someone tries to introduce effective corrective measures, shouting and complaining resound from all quarters.

**Does this mean that there's no plan for how to use the research results – including those relating to the potential impacts?**

**AB:** There is a spirit of progress in research – people want to develop new technologies that help to save the world. Nobody wants someone standing by the wayside saying, 'Wait a minute! First let's see if this is the right direction'. But I do see a strong need for research that uses data and studies to predict the impact of various interventions – for example financial steering measures – thereby providing guidance for the transformation of the energy system.

**RI:** It's also a matter of communication. People do not understand how financial steering measures work ...

**AB:** ... and there's a particular lack of understanding of the system in politics and among the public. Currently, there's a fresh outcry against pumped storage plants, and

a lack of understanding that energy transition cannot be achieved without appropriate energy storage.

**RI:** Behavioral economists and social psychologists are also needed here to study how these things are perceived. How do we foster the willingness to support such change? So far we have not made significant progress.

**AB:** No, not at all!

**Social scientists and economists are also carrying out research at WSL. What is the outcome of this?**

**AB:** These projects sometimes unearth surprising things. One study on how tourists perceived the heightening of the Grimsel Pass dam showed that hydropower was not viewed as green energy. It's not considered to be as positive or innovative as wind, solar or biomass energy. Another WSL study showed that the installation of solar cells on roofs is relatively conflict-free, whereas there are very few places where wind power can be exploited without a risk of conflict.

**How can such findings influence the implementation of energy transition?**

**AB:** The problem is that researchers, politicians and businesspeople speak completely different languages. We need a national network that makes knowledge and technology from the energy sector available for use in industry. This should help foster understanding on both sides and unite the various sectors putting the energy transition into practice.

**RI:** We have to move beyond ideological identities and disputes – who favors renewable energy, who favors nuclear power – the kind of thing we currently see in parliament.



A successful energy transition requires flexibility with regard to electricity grids – and communications networks.

**AB:** In order to get a bird’s-eye view of the whole energy system, individual research disciplines must do a better job of collaborating with each other. Collaboration is essential if the energy transition is to succeed. *(bki)*

**“The biggest challenge, in my opinion, is that we still do not know how to introduce the energy transition into society and industry.”**

A large pile of cut logs and branches, likely fuel wood, is shown in a forest setting. The logs are stacked and surrounded by a dense network of smaller branches and twigs. The background shows green foliage and trees. A text box is overlaid on the left side of the image.

Fuel wood stores are attractive breeding grounds for beetles that live in deadwood. When the wood is chopped up, though, the stores turn out to be a deadly trap for the larvae.



Nowadays, the forest is once again increasingly used as a source of fuel wood. This can create clashes with nature conservation issues, with creatures that live in deadwood coming under particular pressure.

A WSL pilot study on beech forests has shown that the risk of entrapment in fuel wood stores is greater in darker forests than in light ones, and also depends on the dimensions and layering of the wood pieces.

A fuel wood store in a beech forest in Birmensdorf.

## Biomass for the Swiss energy transition. WSL is studying the energy potential of biomass at the Swiss Competence Centers for Energy Research (SCCER), and devotes its attention to both woody and non-woody biomass.

It's peaceful here at this park in the heart of Zurich. Young people sit in groups on the lawn, enjoying the morning sunshine on Platzspitz. Just across from them, a Grün Stadt Zürich employee makes his rounds on a ride-on mower. It's something he and his colleagues across all of Zurich's green spaces do on a regular basis, so that the sun-worshippers can continue to enjoy the lawns. An enormous quantity of grass is heaped together every year – but what happens to this biomass?

As part of his study at WSL, geographer and development planner Georg Müller has set himself the task of finding out how much of this landscape maintenance green waste is accumulated in the canton of Zurich, and how much of it is put to use. He not only investigated grass cuttings from parks and other public green spaces in urban areas, but also non-ligneous cuttings from maintenance of nature reserves, roads and railway lines. What interested him the most in all of this was how much of this plant waste could be converted into energy.

“In the context of energy transition, renewable energy sources are playing an increasingly important role. In this respect, biomass has a part to play, too,” says Müller. In fact, all biomass can be converted into energy. It can either be



Maintenance of roadside verges creates biomass that could be exploited for energy purposes.

burnt to produce warmth or fermented to produce biogas. Biogas production is based on putrefaction processes that occur naturally in moorland and lake beds: microorganisms break down organic substances under airtight conditions and create biogas. This can be collected in a reactor and converted into electricity at a power station, or fed into a natural gas grid after processing. Even the grass cuttings from Platzspitz make their way to the municipal biogas plant every week.

### **Power for 5,000 households**

Of course, landscape maintenance green waste constitutes only a small part of the biomass that can be used for energy purposes. Nevertheless, this kind of energy creation has been on the agenda for some time now in other countries – Germany even subsidizes it with funds from the public purse. In Switzerland, however, the use of herbaceous biomass for energy purposes seems less of a priority. Müller wants to use his work to change this – but that is not his only motivation: “If we use the biomass energy that results from the maintenance of conservation areas, we can combine the concerns of nature conservation and climate protection.” From a climate protection standpoint, the conversion of biomass into energy means that no additional CO<sub>2</sub> is emitted into the air. And when it comes to nature conservation, regular mowing and the removal of cuttings help to promote the diversity of the plant and animal world; for example, in hay meadows.

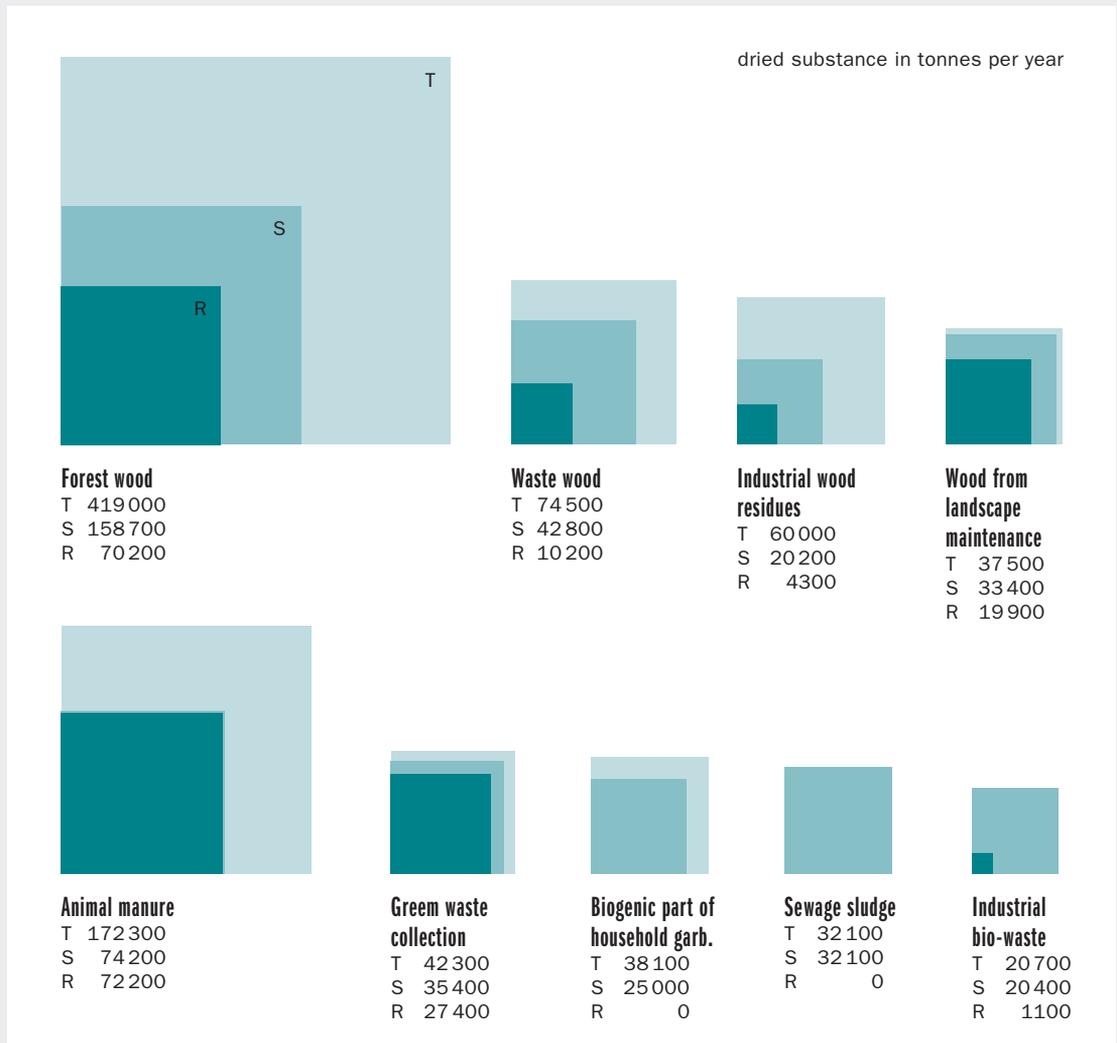
In order to find out how much green waste is available in the canton of Zurich, and how much energy might be obtained from it, Müller relied on existing databases, such as area inventories of various habitat types. Where no data was available, he carried out interviews with the specialists who maintain the various green spaces. In order to make statements that go beyond the canton



Collected organic waste is mulched into particles with a maximum size of 60 mm and fed into the biogas fermenter, where the industrial transformation of non-woody biomass into biogas takes place.

INFOGRAPHIC **Energy biomass resources in canton Aargau**

WSL investigated how many tonnes of dried biomass of all types would theoretically accumulate by 2050 in canton Aargau that could from a present-day perspective be used for sustainable energy. After deducting the biomass already used today, it calculated the additional energy potential that would be available for use in the future. Forest wood and animal manure represented the greatest additional potential by far.



**FOREST WOOD:** All types of forest wood designated for energy purposes. **WASTE WOOD:** Wood from the maintenance and renovation of buildings. **INDUSTRIAL WOOD RESIDUES:** Production waste from companies that treat and process raw timber. **WOOD FROM LANDSCAPE MAINTENANCE:** All ligneous parts of trees and bushes from open fields and populated areas. **ANIMAL MANURE:** Liquid manure and dung from livestock. **GREEN WASTE COLLECTION:** All non-ligneous waste collected by local authorities during park and garden maintenance, etc., as well as household food leftovers. **BIOGENIC PART OF HOUSEHOLD GARBAGE:** Waste from food or plants and other organic waste (paper, cardboard, cork, etc.). **SEWAGE SLUDGE:** Biogenic and organic matter from sewage. **INDUSTRIAL BIO-WASTE:** Residue from food processing, catering, retailers, paper industry.

- T Theoretical potential: total quantity of biomass
- S Sustainable potential: theoretical potential minus a range of technical, ecological, political, legal or economic constraints
- R Remaining sustainable potential: sustainable potential minus the already energetically used potential

of Zurich, he also made projections for the whole of Switzerland. From this it emerged that if green waste from the whole of Switzerland was converted into energy, it would cover the electricity needs of about 25,000 households. Nonetheless, Müller is keen to qualify this: “Farmers today use roughly 40 % to 50 % of green waste as animal feed or straw, particularly cuttings from nature conservation areas. Using this to source energy would not make much sense, since it’s already being used for sustainable purposes.”

The same goes for grass cuttings that are used as mulch – as is the case in a number of parks. This can be ecologically and economically beneficial, and allows a more sparing use of fertilizer. Müller has left these areas out of consideration, calculating only the potential sustainable energy available for use (see infographic for definitions of potential). The projected figure for this stands at about 90,000 gigajoules for the whole of Switzerland, enough to cover the electricity requirements of roughly 5,000 households. Müller sees the greatest potential in biomass growing alongside motorways and cantonal roads. Maintenance services remove this after mowing or mulching for safety reasons, as the material can blow onto the road or clog the drains.

### **Biomass to become more important**

Even if green waste makes only a small contribution to energy transition, Müller is convinced it will become a more significant energy source in future, a statement with which Oliver Thees can only concur. He’s in charge of WSL’s Forest Production Systems research group. Together with Vanessa Burg, Matthias Erni and Renato Lemm, he investigates the potential future role of biomass in the Swiss energy system under the auspices of the BIOSWEET competence center. As part of the Energy Strategy 2050 plan, the Commission for Technology and Innovation (CTI) and the Swiss National Science Foundation (SNSF) have established eight competence centers for energy research – the Swiss Competence Centers for Energy Research (SCCER). SCCER BIOSWEET (BIOmass for SWiss EnErgy fuTure) is one of these.

The vision of Thees and the other researchers from across nine institutions is to double the energy supply derived from biomass by 2050. Most of the institutions within SCCER BIOSWEET focus on technology research; they investigate how biomass can be more efficiently converted into electricity, biogas or liquid fuels in future. Thees and his WSL team are taking a closer look at biomass resources and their availability. First, there is woody biomass, which includes not only forest wood – treetops, branches and thin trunks that are not used for industrial purposes – but also wood from tree and shrub maintenance in urban areas, and road and embankment (‘wood from landscape maintenance’). It can all be used to source energy. Wood from building renovation (‘waste wood’) or production waste from sawmills and carpenters (‘industrial wood residues’) can also be added to this list. Second, there is non-woody biomass, which includes the landscaping green waste mentioned above, animal manure, agricultural crop residues, biogenic waste from households, gardens and industry, and sewage sludge. Since all types of biomass are very different in terms of quantity and energy content, the first thing to do is to establish a comparable basis. For all types, the research team calculated how many tonnes per year of the dried substance are theoretically available and how much could

More information on  
SCCER-BIOSWEET:  
[www.wsl.ch/more/  
biosweet-en](http://www.wsl.ch/more/biosweet-en)

be sustainably used. They then worked from there to calculate the future energy potential, broken down into every region in Switzerland. “Compilation of this information allows us first of all to compare the different types of biomass, and to determine where the most energy can be sourced, both now and in the future,” Thees explains. It should also provide an important decision-making basis for politicians and operators of biomass power plants.

The first phase of the research project comes to a close at the end of 2016, by which point the data for all biomass types will be available. In the second phase, the team will define a variety of energy scenarios and simulate how these might develop by 2050 on the basis of the SCCER BIOSWEET project data. A preliminary study, however, has made it possible to draw some initial conclusions. During the research project Renewable Energies Aargau (see also Diagonal 2/15), one of Thees’ colleagues investigated the different biomass types in canton Aargau, just as SCCER BIOSWEET is now doing for the whole of Switzerland. The project showed that the types of biomass that demonstrated the greatest potential for energy use were animal manure and forest wood (see infographic). Comparison with other renewable energy sources in Aargau showed that the contribution of biomass to the renewable energy supply would nonetheless remain modest. For Thees, though, this is not a reason to sit back and give up: “In contrast to solar or wind energy, biomass energy is storable, which makes it an effective long-term solution to balance out fluctuating supplies of solar and wind energy. It’s also the only energy source to produce heat, power and fuel. I’m convinced that biomass will play an increasingly significant role in the overall energy system in future, even if only in small quantities.”

*(chu)*

- |   |   |
|---|---|
| 1 Water diversion   | 18 Fish migration   |
| 2 Land submersion   | 19 pH level of water  |
| 3 Avalanches and landslides                               | 20 Water temperature  |
| 4 Glacier and permafrost melt                             | 21 Bank erosion   |
| 5 Tourism and leisure                                     | 22 Drought (prevention)   |
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| 10 Sediment bypass tunnel                                 | 27 Dam infrastructure and access roads                                    |
| 11 Artificial snow production                             | 28 Hardwood floodplain forests  |
| 12 Electricity transmission infrastructure                | 29 Groundwater  |
| 13 PSHP operation (generation, pump-mode)                 | 30 Drinking water   |
| 14 Gravel/sediment extraction                             | 31 Irrigation   |
| 15 Sediment replenishment                                 | 32 Decommissioning NPPs   |
| 16 Riparian habitats                                      | 33 Flood (prevention)   |
| 17 Balancing reservoir                                    | 34 International electricity feed-in (exchange) and power sector policies |

# INFOGRAPHIC Pumped storage plants – a green solution?

Roughly 55 % of Swiss electricity is produced using hydropower – a rising trend. The construction, expansion and rebuilding of hydroelectric plants is controversial, and brings a number of different interests into collision with each other. WSL developed this diagram during a workshop attended by various experts from Switzerland and Austria. It shows which areas of our environment, economy and society are affected by the use of hydropower and pumped storage, and looks at factors that influence the use of hydropower. Alongside the potential risk of conflict, this form of renewable energy also presents a large number of opportunities.



First published in: Björnson Gurung *et al.* (2016) "Rethinking Pumped Storage Hydropower in the European Alps" in the journal Mountain Research and Development 36(2). DOI: [dx.doi.org/10.1659/MRD-JOURNAL-D-15-00069.1](https://doi.org/10.1659/MRD-JOURNAL-D-15-00069.1)

# SUN AND WIND **Taking renewable energy into the future**

## Production of renewable energy from the sun and wind requires space. WSL is investigating opportunities and likely conflicts in a changing landscape.

Schaffhauserplatz, in Zurich's District 6: as in so many other places, an apartment building is being refurbished. If you study the building a little closer, the facade stands out: cables are protruding from where matte-gray glass plates will soon be installed. This is no ordinary facade: it's fitted with solar cells, which, together with a photovoltaic system on the roof, will provide all the electricity that the residents need – and more.

The production of renewable energy requires space. In the case of an apartment building, this space is provided by roofs and facades. Conflicts are unlikely as the solar panels are elegantly integrated into facades or roofs. But conflicts occur quite often: in many locations that are generally suitable for the production of renewable energy, the construction of wind turbines or photovoltaic systems would result in the curtailing of other ecosystem services. Thus, the aesthetic value of the landscape could be diminished or living space for plants and animals might be reduced.

If construction of infrastructure for renewable energy production is restricted to areas where the risk of conflict is low, total energy production will be significantly reduced. A balancing of interests is therefore necessary, as renewable energy sources also offer remarkable opportunities. As part of the Energy Change Impact research program, Janine Bolliger and her colleagues examined how much solar and wind energy could be produced in Switzerland with minimal conflict over land use, and the economic opportunities this might create. The researchers considered future land-use scenarios, taking into account expected advances in technology.

More information:  
[www.wsl.ch/more/freo](http://www.wsl.ch/more/freo)

### **The opportunities of urbanization**

The researchers carried out interviews with experts in order to find out the kinds of technological advances we can expect in the future. Technology experts believe that by 2035 wind turbines will be more efficient than today, even at low wind speeds. Their transport and set-up will also become simpler, making them suitable for installation in isolated areas. The efficiency of solar cells will increase by at least 20 % compared to today's levels. The design of solar panels will also become more appealing, either more colorful or invisibly integrated into windows – all contributing to higher acceptance by the public.

A daring vision of 2035: solar energy can be used more effectively, since all land-use scenarios see an increasing number of built-up areas in Switzerland. Increases in built-up areas will facilitate the installation of solar cells on buildings (roofs, facades), leading to an increase in solar electricity potential of 20 % to 50 % in 2035 compared to 2009. Solar energy should also make a higher contribution than previously assumed to compensate for some of the anticipated energy deficits.

The situation is different for wind energy, as wind turbines are more likely to cause conflicts compared to solar panels (noise, aesthetics and nature conservation concerns). There is a distinction, then, between the total power we can produce and the power we can exploit with a low risk of conflict. This conflict of interest is unlikely to be resolved in future, regardless of technological innovations. As both populated and wooded areas are due to increase by 2035, fewer suitable locations will be available for wind turbines. The improved efficiency of wind turbines may well offset this, but the difference between potential energy power production and low-conflict energy power production remains large in all future land-use scenarios, meaning that future projections for wind energy are comparable to the current situation.



The photovoltaic facade of this skyscraper in Zurich Leimbach supplies around 85,000 kWh of power per year, covering a third of residents' energy consumption.

Researchers are also assessing how wind and solar energy benefit the local economy in rural regions of Switzerland (Surselva, Goms, upper Emmental and Val de Ruz). Although the net added value varies by region, it remains 5 % below today's value in all cases. The reason is that the installations are primarily manufactured abroad, and, with the exception of maintenance, bring in very little additional business to the region.

### **Calculating optimal locations for renewable electricity sources**

What are the future prospects for wind energy? Bolliger is keen to qualify: “Our results apply to Switzerland, where the beauty of the landscape is very highly valued. Many people prefer landscapes that are not visually or acoustically disturbed. It's likely, though, that social acceptance may change in future.” What is clear is that not all potential locations are suitable for wind turbines. “In an optimal location for renewable energy, the impacts on the ecosystem are at least balanced out by the amount of electricity generated from renewable sources”, says Felix Kienast, head of the Landscape Research Center and Professor of Landscape Ecology at ETH. “Assessments of trade-offs between electricity gain and conflicts with other ecosystem services certainly facilitate the search for locations and the decision to build.” Such evaluations may be conducted using optimization software. Kienast and his colleagues used such an approach to determine the areas with the highest energy potential at the smallest possible cost for other ecosystem services.

At Schaffhauserplatz in Zurich, no conflict evaluation was needed. The apartment building will be completed in autumn 2016, ready to produce its own electricity from renewable sources. Its smooth facade will still stand out among the plastered walls of the neighboring houses – but perhaps not for much longer. *(lbo)*

Doris Schneider Mathis,  
Birmensdorf

“Whenever I’m homesick for Grisons and the clouds are a bit low and oppressive, I can always find a view of the horizon near my house in Bonstetten. On long walks on the Feldenmas plateau, I enjoy the peace and security of the surrounding woods.”

#### INSECTS UP CLOSE

Doris Schneider Mathis’ daily work is all about insects. As a technical employee, she is responsible for insect sampling in the field and identification of the insects under the microscope.

She also trains biology laboratory assistants and interns in the field of entomology. “I enjoy working with young people – it enriches my working day.”

## FORESTS Oak or oak? Genetics assists with species identification



Taking leaf samples from oak trees is far from simple.

It's all very complicated: pedunculate oak has very short petioles and auricles on the leaf base. The leaves of the sessile oak have no auricles; instead, they have stellate hairs on their underside, similar to downy oak leaves, although these have clustered hairs. Even the experts struggle to reliably identify oaks every time – particularly as the species also hybridize. Since the three oak species are likely to cope with future climate conditions such as drought with varying degrees of success, it's important that researchers and forest management are able to identify them correctly.

As part of FOEN and WSL's 'Forest and climate change' research program, Christian Rellstab investigated whether genetic markers, leaf characteristics (leaf morphology) or a combination of the two most reliably allow for species identification. He and his colleagues collected leaves in 71 oak tree populations and from 20 trees in each population. They used these to investigate the genetic fingerprint of the trees in the laboratory, and to record features such as shape, the course of leaf veins and the tiny hairs on the underside of the leaf using a stereo lens.

The most reliable differentiation was achieved by the combination of genetics and leaf characteristics. "Many people see traditional morphological methods and genetics as antithetical," explains Rellstab, "but when it comes to species that interbreed and are morphologically similar, they complement each other." Nevertheless, his study also recommends restricting analyses to genetics, given this is being examined anyway. Morphological analyses are particularly time-consuming, and purely genetic examinations deliver results that are almost as good as those achieved through a combination of the two methods. Furthermore, hybrid trees do not always demonstrate intermediary morphological features – genetic analysis, on the other hand, delivers clarity. (*bio*)

[www.wsl.ch/more/forests-climate-en](http://www.wsl.ch/more/forests-climate-en)

## FORESTS Are beech trees from inner alpine dry valleys adapted to drought?

Approximately every fourth forest tree in central Switzerland is a beech – and in the Jura every third. This makes the beech the most common tree species in the lower-lying regions (the foothill and lower montane altitude zones) of our country. But there might be trouble in store in future: beeches are poorly equipped for future climate changes, as they do not cope well with extremely dry summers. Ecophysiologicalists Marcus Schaub and Matthias Arend have taken an interest in beech trees that have long grown in dry locations, but which are also adapted to the climatic conditions of the Swiss winter. Could they perhaps serve as progenitors for future generations of beech tree when conditions in central Switzerland become drier?

In spring 2011, Arend replanted young beeches from the dry forest populations of the Rhone and Rhine valleys into the Model Ecosystem Facility (MODOEK) in Birmensdorf – a testing plant at which soil dryness can be precisely controlled. For the purposes of comparison, Arend also replanted beeches from considerably damper forest populations, also from the Rhone and Rhine valleys. In the summers of 2013 and 2014, half the trees were exposed to an artificial, controlled summer drought, while the other half grew in damper conditions. The researchers investigated how the trees grew during and after the drought, if their metabolism changed and how they developed in different seasons. As expected, the photosynthetic rates of the trees from dry forest populations diminished less, and made quicker recoveries

after the drought. Their yearly stem growth was also less affected. In an astonishing result, trees of all origins demonstrated a higher photosynthetic rate after the drought than trees that had always had enough water. Thus, they were able to compensate for some of the loss suffered. “This was something we hadn’t counted on,” says Schaub.

Forest Policy 2020’s precautionary adaptation strategy recommends that forest managers use trees from species and origins that tolerate dry conditions well. This experiment demonstrates that some Swiss beech trees have the origins necessary for this.

*(bio)*



At the Model Ecosystem Facility, trees grow under conditions similar to those in nature, but which can be adjusted for experimental purposes.

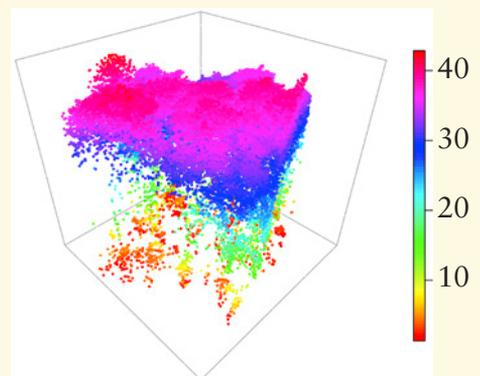
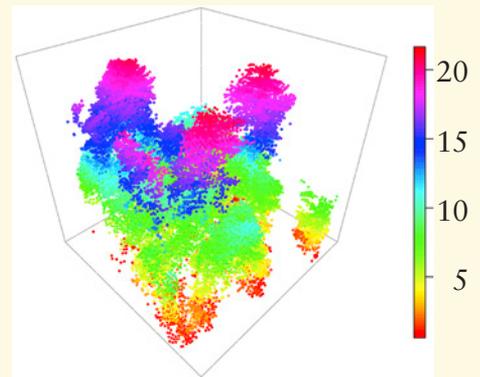
# BIODIVERSITY Remote sensing enables comprehensive analysis of forest structures and biodiversity

Florian Zellweger has been fascinated by forests since he was a child. While he was studying geography at the University of Zurich, he immersed himself in the diversity of our forests and at the same time learned how to use geographical information systems and remote sensing data – a combination he was able to put to optimal use in his doctoral studies at WSL.

Not every forest has the same diversity. Various factors influence the biodiversity of a forest; for example, the climate, soil characteristics and the forest structure. The more varied the structure, the greater

the variety of micro-habitats available to plants and animals. It takes considerable effort to collect data on forest structure in the field; for example, how trees and bushes are distributed or how much light reaches the ground through the canopy.

Nowadays, it's easier to do this from the air: large parts of Switzerland are documented at regular intervals by plane using laser scanning. Vast LiDAR (Light Detection And Ranging) datasets on the surface structure of the landscape are available, but the potential of this data is in part untapped: “The 3D data can be used in a wide variety of ways and



A mountain forest (top) and a beech forest (below) with the corresponding LiDAR point cloud diagrams showing the three-dimensional forest structure.

can also be linked with other data. This is not happening enough, particularly in the area of biodiversity,” says Zellweger.

### Structure-dependent

Zellweger wanted to find out if the biodiversity of a forest could be predicted using LiDAR datasets. “Data on forest structure is important in that the structure of a forest can be influenced by silviculture measures,” he explains. “If we know which structures promote biodiversity, we can provide forest management with appropriate recommendations.” In order to find this out, he combined data on the diversity and habitats of individual species groups with LiDAR data. The results are encouraging: he was able to prove, inter alia, that forest structure data can reliably predict the presence of many butterflies. The more diverse the shrub layer is in a forest – for example, along well-structured forest edges – the greater the diversity of butterflies. Many butterflies and caterpillars find food and protection in shrubs.

Additionally, Zellweger was able to show that the forest structure also determines how different species of bats use their habitats. Bat species often found towards the interior of a forest were less active in forest land with consistently dense, vertical foliage and many branches. These structures disturb echolocation calls, and thus the bat’s ability to navigate.

### Added value through new connections

Forest structure data from remote sensing is also suitable for producing comprehensive predictions of the biodiversity in Swiss forests. The advantage of this method is that it is more practical than recordings of forest

structures in the field and can be applied to areas of any size. Changes in forests caused by storms or silviculture measures, for example, can also be easily measured in this way. Zellweger, for one, is certain: “Evaluation of datasets from remote sensing is still far from complete.” *(lbo)*

[www.wsl.ch/more/forest-structure](http://www.wsl.ch/more/forest-structure)



Structure-rich shrub layers promote butterfly diversity. In the photo, a White Admiral.



Collecting vegetation samples at the Hinterrhein – Alp Piänetsch automated weather station in Grisons.

Automated weather stations measure wind, temperature, snow depth and other data. But these IMIS weather stations, operated by cantonal authorities, can do much more. Since the 1990s, their ultrasonic sensors have also been recording how plants within a 75 cm radius have been growing. With this unique dataset, collected from around 130 stations, researchers of SLF, WSL and the University of Neuchâtel have been able to reconstruct how vegetation has developed over the course of the last 20 years, and how alpine plants will react to climate change in the future.

The first results show that the duration of snow cover at the stations analyzed has reduced markedly in recent decades – due primarily to earlier snow melt in the spring. The

plants reacted to these changing environmental conditions accordingly: the start of their growth period showed a strong correlation with the date when the snow began to melt, regardless of the station’s elevation. In other words, the sooner the area became snow-free, the sooner the plants woke from their hibernation. Plants developed more slowly, though, in years when the snow melted early than in years with a late snow-melt. The air temperature turned out to be responsible for this effect; it wasn’t high enough earlier in the year to provide the plants with sufficient warmth for their growth. (chu)

[www.slf.ch/more/imis-vegetation-en](http://www.slf.ch/more/imis-vegetation-en)

# LANDSCAPES What municipalities are doing to counter urban sprawl

Between 1985 and 2009, the amount of built-up land in Switzerland increased by an area equivalent to Lake Geneva. In many places, the expansion of built-up areas results in a loss of farm land and increased energy consumption and infrastructure costs. Municipalities play a key role in the struggle against overdevelopment. They are required to develop within the limits of cantonal structure plans, but in doing so, they must reconcile a host of different interests.

With the support of the 'Sustainable use of soil as a resource' National Research Program (NFP 68), WSL researchers assessed responses from 1,619 municipalities on the question of which measures and organizational structures have been employed in recent decades to manage and develop the land. The most common measures taken were aimed at urban densification and the strategic development of the municipality. Local authorities often decide that parcels of land can – or indeed should – be developed with more and higher buildings, or they designate green conservation zones to limit urban expansion.

Large municipalities frequently control building projects on larger areas with special district plans and architectural competitions. Particularly in recent times, new land-use designations have been restricted, although only rarely. Smaller municipalities, on the other hand, try to fill centrally located empty sites instead of allowing the settlements to expand. This can be accomplished by stipulating that an area must be developed within a certain period of

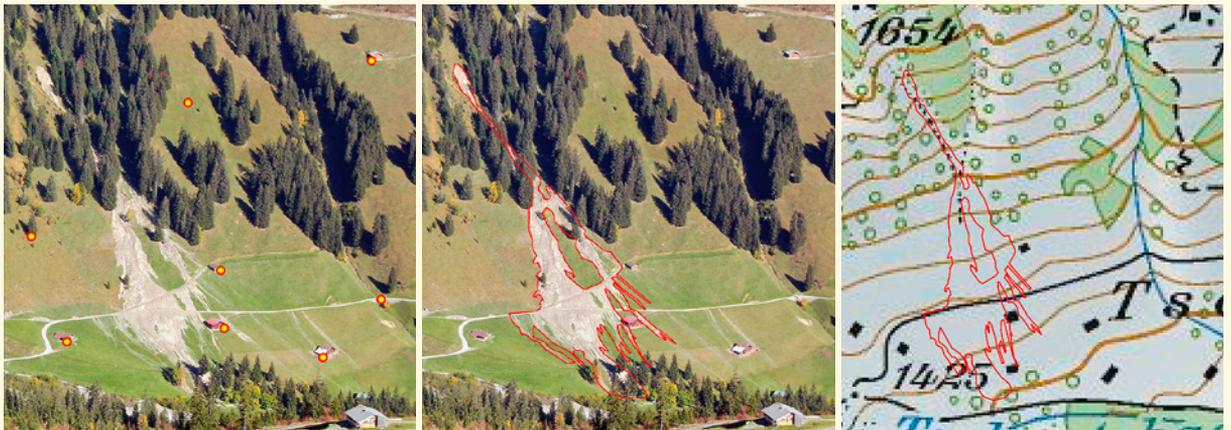
time after being assigned to a building zone.

The survey gives the first systematic overview of how spatial planning is organized at a local level, and also offers a chance to compare municipalities and regions with each other. Other relationships can also be examined using this data: for example, the influence of particular steering measures on urban sprawl. (bki)



Building works on the tallest building in Canton Zug, Park Tower.

# LANDSCAPES Monoplotting: Using photography to record landscape changes



Case study of a landslide in Tschentetal/Egerle, Adelboden (BE). a) Original image from 18 October 2011, with control points (yellow dots with red border), b) original image with digitized extent of debris flow (red lines) c) detailed map with debris flow marked. Due to the finely branched spread of the deposits, mapping in the field would have been extremely costly.

Marco Conedera was astonished when the request came in from Rio de Janeiro. The coordinator of the photography division of the Instituto Moreira Salles, an organization for cultural promotion, had stumbled across his monoplotting tool on the internet. Claudio Bozzini, Patrik Krebs and Conedera had developed the free software at the WSL site in Ticino. With monoplotting, landscape features – such as bodies of water or rocky promontories – can be digitized from any kind of photograph and transmitted with an accuracy ranging from tens of centimeters to a few meters. The only conditions the photo has to meet are that it must be available in digital format with good image resolution, and feature four or more control points (or landscape elements) that are clearly recognizable both on the photo and on a map. Using these control points, the photo can be georeferenced, which means that every pixel on the image is assigned a real coordinate.

This technique opens up completely new possibilities. Based on the

vast treasure trove of historical photographs lying around unused in so many archives, it is now possible for the first time to quantitatively document how the landscape is changing – for example, by how many meters the tree line has risen, or how many meters of terracing once ran through a now wooded area. It is a technique that has drawn the interest of the Instituto Moreira Salles. The institute wants to use the monoplotting tool to quantitatively evaluate more than 10,000 images of Rio and other areas of Brazil, a unique collection that has existed since the 19<sup>th</sup> century.

## **A better understanding of the scope of natural events**

The software can be used for more than just analysis of historical photographs, though. It also has considerable potential when it comes to documentation of contemporary natural events. Debris flows that occur simultaneously or in impassable areas, for example, can often be recorded only through targeted photography. The same is true of particularly

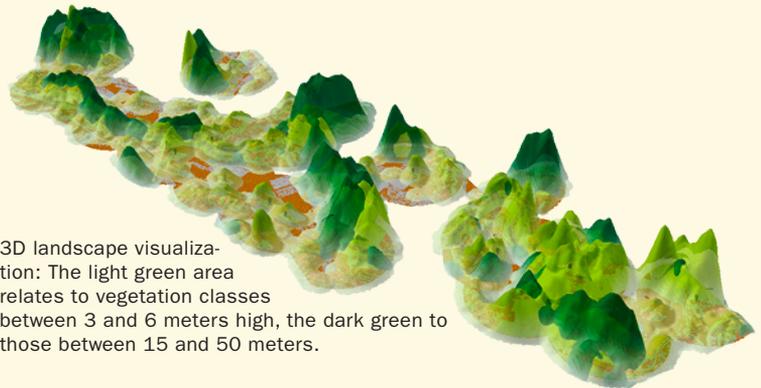
severe landslides, where the priority is on initiation of rescue operations. Monoplotting enables evaluation of these images later on in the calm of the office, and calculation of the exact extent of debris flow residue. It is an asset that has also caught the attention of the Federal Office for the Environment, which has commissioned Conedera and his team to program an interface capable of importing photos analyzed using the monoplotting tool into StorMe. StorMe is a database system used for land registries of natural hazard events, maintained by the cantons on

behalf of the federal government. In future, cantonal employees will be able to form an immediate idea of some of the damage using the monoplotting tool, making the process of keeping an account of natural events much more straightforward. *(chu)*

[www.wsl.ch/more/monoplotting-en](http://www.wsl.ch/more/monoplotting-en)

## LANDSCAPES The 3D structure of woody vegetation – accessible thanks to a new tool

For his Master's thesis, environmental scientist Pierre Cothereau set himself a very particular goal: any researcher who is interested in the 3D structure of woody vegetation should be able to extract this information from remote sensing data in user-defined height classes in a desired region – even with no specialist knowledge of remote sensing or GIS. To this end, he developed the Vertical Vegetation Structure Classifier (VVSC). This is a toolbox for the mapping platform ArcGIS that classifies the vegetation – as derived from LiDAR data in a selected region – into user-defined height classes. Thanks to Cothereau's tool, researchers can now make use of these datasets in a straightforward fashion. The 3D information derived from VVSC can be combined with other data on the ecosystem's properties, for example land use or climate, in order to analyze features such as structural networks or other aspects of connectivity within the



3D landscape visualization: The light green area relates to vegetation classes between 3 and 6 meters high, the dark green to those between 15 and 50 meters.

landscape in 3D. His achievement has gained considerable recognition: he won the Young Scholar Award from Esri, one of the leading producers of geographic information system (GIS) software, and was able to present his project to an audience of international experts in San Diego, US. *(ces)*

[www.wsl.ch/more/vvsc-en](http://www.wsl.ch/more/vvsc-en)

# The effectiveness of plants as slope stabilizers



Plants can prevent landslides, but not in all cases: in pastures, for example, intensive grazing and fertilization can interfere with their stabilizing effect.

As well as debris flows, large storms often also cause landslides of varying severity which can damage land and infrastructure. A sound layer of plant cover may help protect against erosion and landslides. Until now, though, it wasn't known to what extent, or which plant combinations should be used. New results have been delivered by WSL's SOSTANAH (SOil STAbility and NATural Hazards) project, which is a part of the 'Sustainable use of soil as a resource' National Program (NFP 68).

To underpin the slope fortifications with some solid figures, doctoral student Anil Yildiz investigated soil samples from two landslide areas in the laboratory. Using a shearing

apparatus, he measured the strength required to cause a slope to start slipping – with and without alder, grass and clover. It emerged that after only six months of growth the plants had greatly strengthened the soil. A real-life slope would therefore remain stable, even with an incline 5° steeper than can be expected from the soil material.

The effect of planting woods was verified by a study on the previously unvegetated erosion and landslide zone of Hexenrübi (NW). Willow trees planted between 2009 and 2011 have created abundant biomass, both above and below ground. The next big storm will show how much the plantings have improved the slope's stability.

The results of the various SOSTANAH sub-projects both confirm and complement existing guidelines for the management of protection forests (NaiS). A few lessons from the projects: slopes should contain as many species, age groups and root structures as possible, intensive grazing and fertilization can interfere with the protective effect, and vertical paths of more than 20 m down the fall line should be avoided if possible.

WSL researchers used statistical methods to investigate the effect of forest structure during landslide events. They used an example from Sachseln (OW), where heavy rainfall caused over 500 landslides in 1997.

The calculations indicate that about four fifths of the more than 100 landslides taken into account would not have occurred under optimal management. It is estimated that the corresponding care and maintenance of the affected forest areas would cost only a tenth of total cost of damages. *(bki)*

[www.slf.ch/more/sostanah-en](http://www.slf.ch/more/sostanah-en)

## NATURAL HAZARDS How great is the risk of avalanche fatalities on snow tours?

‘Muotathal (SZ), 27 February 2016: Avalanche sweeps ski tourer to his death.’ Every winter, we read reports such as this in the press. An average of 23 people lose their lives to avalanches every year in Switzerland. The victims are almost always snow sports enthusiasts who have ventured off piste. We are used to hearing in the wake of an avalanche accident that snow sports enthusiasts run much greater risks than others. Are snow tours particularly dangerous, then? Until now, the lack of solid data meant that all one could do was speculate.

### **Snow touring risks similar to those of road traffic**

The avalanche risk here denotes the likelihood that a tourer might lose their life to an avalanche during a day’s touring or over the course of a year. In order to assess the risk of



Men aged between 30 and 60 who go on ski tours run the highest risk of dying in an avalanche.

snow touring, the number of fatalities is set against touring activity in its entirety in the mountains during winter. For many years, SLF has been recording the accidents in detail. The number of people heading out in the

backcountry, however, is significantly more difficult to determine. The Federal Office of Sport's 'Sport Switzerland' studies are now delivering the first reliable data. About 23,000 people living in Switzerland were interviewed about their sporting habits. The survey showed, inter alia, how often members of the public go on snow tours.

Kurt Winkler, an avalanche forecaster at SLF, set these figures against the number of avalanche accidents and was thus able to calculate the risk of a deadly avalanche for the first time based on statistics. "The risk of an active tourer of dying on a tour in the backcountry within the period of one year is roughly equal to the risk of dying on the roads within the same timeframe," Winkler explains. In any case, this risk is not evenly distributed: The risk to snowshoe walkers is six times smaller than the risk to ski tourers. Winkler suspects that this is primarily because the majority of snowshoe walkers stick to relatively straightforward and therefore less dangerous terrain. If snowshoe walkers are struck by an avalanche, though, their chances of surviving are significantly worse. "This shows that the process of companion rescue isn't working well enough in these groups. This is something that should be practiced on rescue courses," Winkler recommends.

It is worth noting that the risk to men is three and a half times greater than the risk to women. In other words, a woman who is out on the snow for an entire week has the same risk as a man who tours for only a weekend. The age group from 30 to 60 seems to run a somewhat higher risk than those on either side of this bracket. "In terms of prevention, we should be making an in-

creased effort to address middle-aged men who go on ski tours," says Winkler.

### **Weaker old snow is critical**

Frank Techel, also an avalanche forecaster at SLF, compared the frequency of avalanche accidents in various regions against the number of entries on online portals where Alpinists document their tours. He was able to show that the risk of being caught in an avalanche increases not only with each level of the danger scale, but is also greater in the inner alpine regions of Valais and Grisons than in the rest of the Swiss Alps, because weaker old snow appears more frequently in these areas. However, neither the weather nor the day of the week had any bearing on the risk. *(mbe)*

Anil Yildiz,  
Birmensdorf

“The city offers me something I don’t often find in nature: contact with other people. Here on Langstrasse in Zurich, I meet up with my friends to chat and get to know new people.”



#### A VIEW OF THE GROUND

Plant roots help to stabilize steep slopes susceptible to failure. In his doctoral thesis, Anil Yildiz investigates how this effect could be measured. The civil engineer works with researchers from bi-

ology, ecology and forestry science sectors. “I really value the collaboration in an interdisciplinary team. We look at the same object from different angles.”

## SNOW AND ICE    Less water is now stored in the Alps in the form of snow



Enormous quantities of water are stored seasonally in the Alps in the form of snow.

Some of the winter precipitation in the Alps is temporarily stored as snow, which is then available as meltwater in spring and summer and can be used in electricity production, agriculture and as drinking water. Seasonal fluctuations in precipitation can thus be partly compensated for. In her master's thesis at SLF, Anna-Maria Tilg conducted the first investigation into changes in the snow water equivalent (the amount of water produced when the snow has completely melted) at more than 40 measuring stations in four alpine countries. Although the stations are distributed over a large range of altitudes and a wide variety of climate regions, she discovered some astonishingly uniform trends across the Alps over the past 45 years. While the

snow water equivalent changed very little in winter, it had decreased markedly on the reporting date of 1 April at about half the stations during the period of time investigated. The reason for this was not just the rise in temperature, but also the lower amount of spring precipitation seen in recent years. If, as expected, temperatures continue to rise, alpine rivers will carry considerably less water in summer, as the greater part of the snowmelt will occur earlier in the year. *(mhe)*

[www.slf.ch/more/swr-en](http://www.slf.ch/more/swr-en)

# SNOW AND ICE Influencing freerider behavior with role models

The new snow glistens untouched in the sunlight. Three, maybe four curves beyond the piste and one daring leap over the crest of a hill, four freeriders are already gliding towards a wildlife reserve. Here, a board depicting two furry toy animals reminds them not to disturb the wild animals.

The board is part of the 'Respect Wildlife' campaign, commissioned by the Federal Office for the Environment (FOEN), the Swiss Alpine Club and various other associations, and has been designed specifically with freeriders in mind. The core of the campaign consists of short videos featuring the two toy animals, Toni and Geri, and showing well-known freeriders in action. Role models on the freerider scene, who had been convinced to support the cause of wildlife protection, have been sharing the videos on social media.

## Evaluations show that the campaign works

WSL evaluated the campaign in the winters of 2013/14 and 2015/16 through surveys in two ski areas. The results were positive: in Laax, where the campaign has been active, awareness of the campaign has risen significantly, as has the willingness of survey participants to respect wildlife reserves. The positive effects of the campaign were also evident at Flumserberg, which had neither videos nor boards, thanks to the spread of the video online.

Earlier investigations by WSL showed that snowshoe and ski tourers are more likely to support wildlife protection than freeriders,

and that the usual forms of information are enough to persuade them to respect wild animals. For freeriders, though, new approaches are required: "The decision to design and carry out this campaign with a target audience in mind, and in collaboration with role models from that target group, was what led to its success," explains Marcel Hunziker, who led the evaluation of the 'Respect Wildlife' campaign. (lbo)

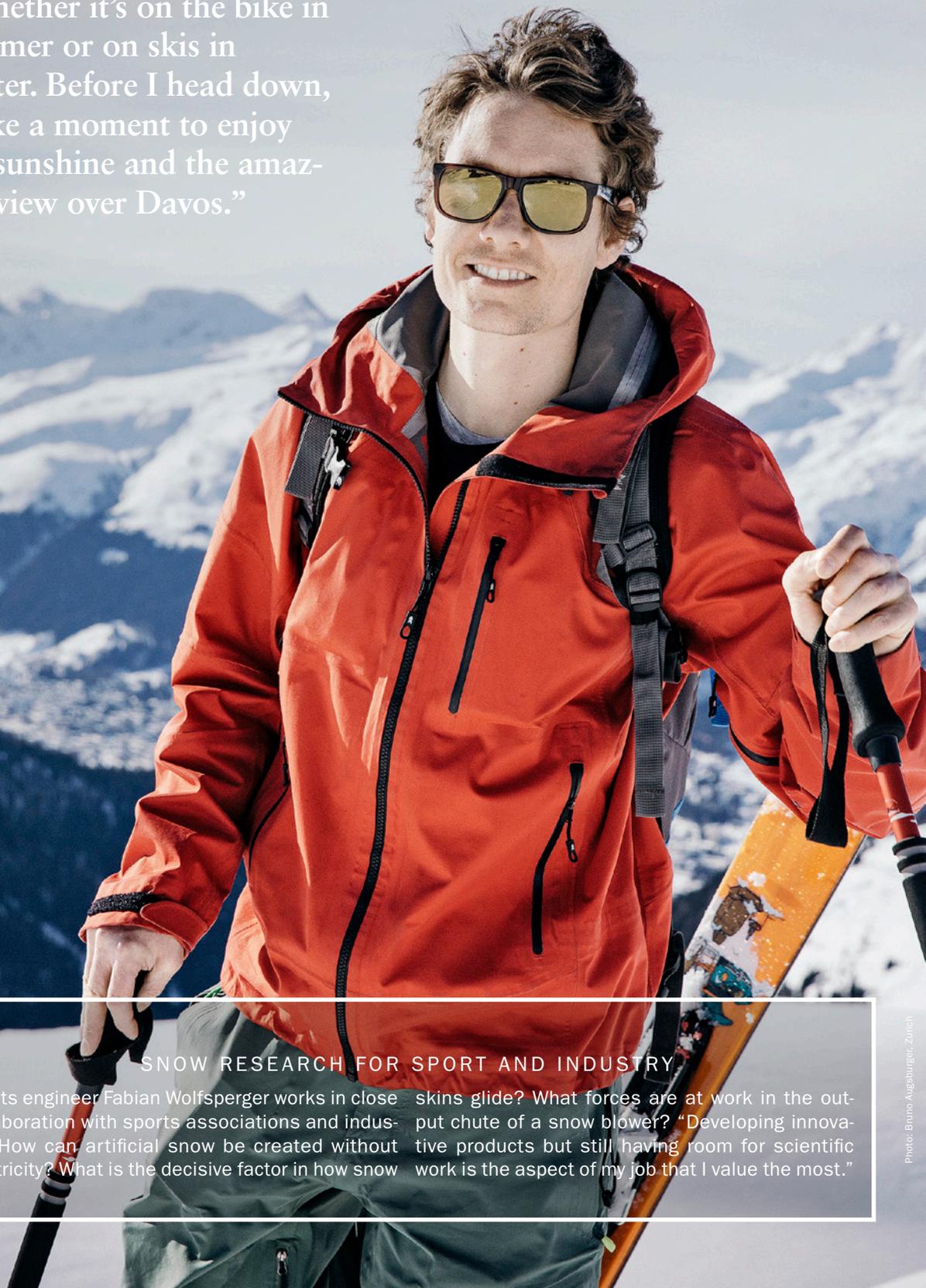
[www.wsl.ch/more/freerider-en](http://www.wsl.ch/more/freerider-en)



The two toy animals, Toni and Geri, remind freeriders not to disturb wild animals while off piste.

Fabian Wolfsperger,  
Davos

“The descent from Pischa is one of the most beautiful downhill journeys I know – whether it’s on the bike in summer or on skis in winter. Before I head down, I take a moment to enjoy the sunshine and the amazing view over Davos.”



#### SNOW RESEARCH FOR SPORT AND INDUSTRY

Sports engineer Fabian Wolfsperger works in close collaboration with sports associations and industry: How can artificial snow be created without electricity? What is the decisive factor in how snow

skins glide? What forces are at work in the output chute of a snow blower? “Developing innovative products but still having room for scientific work is the aspect of my job that I value the most.”



Forest reserves are designated to conserve species and processes. While in special forest reserves forestry interventions for promoting certain plant or animal species are explicitly part of the reserve management, human interventions are strictly prohibited in natural forest reserves. Thereby, natural processes are promoted, creating systems that mimic those of pristine forests and provide habitats for rare and threatened animal and plant species. WSL is investigating the temporal development of forest reserves and what distinguishes them from managed forests, among other things.

DIAGONAL can be ordered free of charge: [www.wsl.ch/diagonal](http://www.wsl.ch/diagonal)

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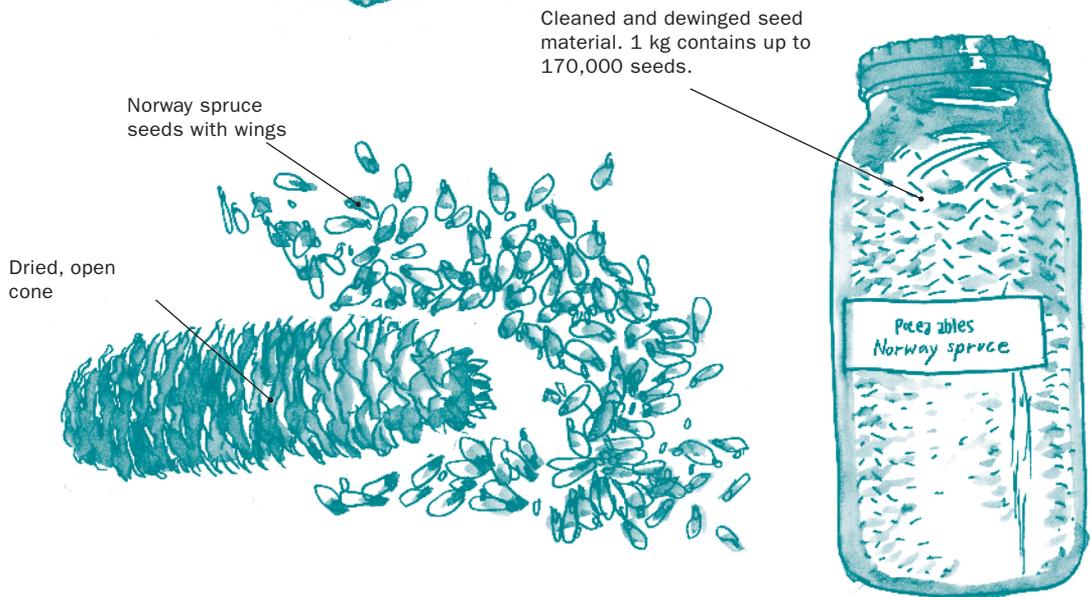
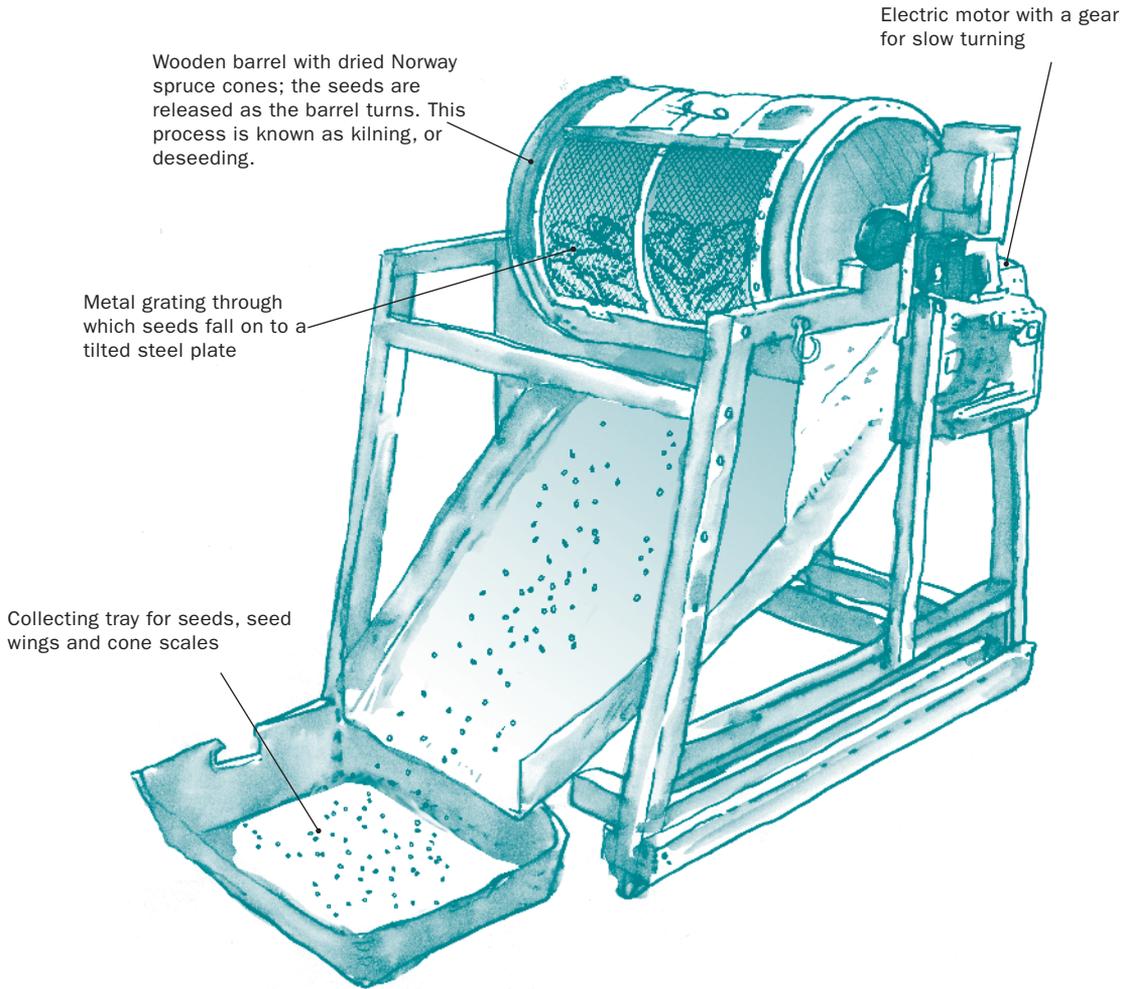
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## PEOPLE



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

## SEED KILNING BARREL



WSL harvests and kilns forest seed material, and operates the national seed agency, which offers seed material to forestry enterprises and tree nurseries. In a refrigerated storage room, WSL stores up to 60-year-old Norway spruce seeds from a variety of origins, as well as seed material from a further 50 tree species and shrubs.

Video at:  
[www.wsl.ch/object](http://www.wsl.ch/object)





**Weather stations:** viewing plant growth using ultrasound technology, p. 24



**Beech trees and drought: surviving with less water, p. 21**

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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 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 center and part of the ETH Domain. You can find WSL's annual report at: [www.wsl.ch/more/annualreport](http://www.wsl.ch/more/annualreport).

