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Self-Assessment Report

WSL Evaluation 2022, Volume 2

Swiss Federal Institute for Forest, Snow and Landscape Research WSL

WSL Institute for Snow and Avalanche Research SLF

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p. 60: S. Margreth; p. 70: S. Fink; p. 71: S. Gindraux

Research for People and the Environment: The Swiss Federal Institute for Forest Snow and Landscape Research WSL monitors and studies forest, landscape, biodiversity, natural hazards, and snow and ice. WSL is a research institute of the Swiss Confederation and part of the ETH Domain. The WSL Institute for Snow and Avalanche Research SLF has been part of the WSL since 1989.

Table of contents

Preamble

The second volume of this self-assessment report provides a short overview of the scopes and tasks of all organizational units of WSL. Overall, WSL has:

- 12 research units
- 7 support units (including the joint library Lib4RI)
- 7 programs
- 3 centers

An organizational chart and a conceptual view of how WSL is organized are available on pages x and x and explained in further detail in Section 3 of Volume 1.

In the following sections, the description of each organizational unit, program or center is divided into two or three sub-sections:

i. Aims and scope
ii. Facts and figures
iii. Major achievements of research units, programs and the Climate Change, Extremes and Natural Hazards in Alpine Regions Research Centre (CERC)

i. Aims and scope of unit

This sub-section comprises a description of the aims and scope of each research unit, program or center and its contributions to the national tasks, if applicable. For support units, the description focuses on their scope and main tasks in supporting WSL. A link to the website of each unit is provided in the margin.

The pictograms in the margin of the research unit descriptions represent the main (core) thematic areas addressed by the unit, in order of importance. The core thematic areas of WSL are:


Forest


Biodiversity


Landscape


Natural hazards


Snow and ice

ii. Facts and figures

Different facts and figures have been selected for research units, support units, programs and centers, as these units have different objectives (see Section 3 in Volume 1). This sub-section contains the following information:

i. Personnel and financial resources for research units and support units
i. Scientific indicators representing the output and activities of research units
i. Main services provided by support units
i. Core thematic areas addressed in programs and centers, and the involvement of specific research units

The legend for the facts and figures is presented on pages 8–9.

iii. Major achievements since 2019

For research units, programs and CERC, three to four achievements since 2019 (or since 2021 for CERC) are presented. These achievements are described briefly, and links are provided for websites where further information is available.

Organizational chart

1.10.2022

Directorate

Director
Prof. Dr. Beate Jessel

Deputy Director
Dr. Christoph Hegg

Members
Prof. h.c. Dr. Anna Hersperger
Prof. Dr. Rolf Holderegger
Birgit Ottmer
Prof. Dr. Jürg Schweizer
Dr. Thomas Wohlgemuth

Communication
Birgit Ottmer

Directorate Support

Research Units

Prof. Dr. Beate Jessel

- **Forest Resources and Management** – Dr. Marco Ferretti
- **Forest Dynamics** – Dr. Thomas Wohlgemuth a.i.
- **Forest Soils and Biogeochemistry** – Dr. Ivano Brunner
- **Forest Health and Biotic Interactions** – Dr. Eckehard G. Brockerhoff
- **Community Ecology** – Dr. Marco Conedera
- **Biodiversity and Conservation Biology** – Prof. Dr. Rolf Holderegger
- **Land Change Science** – Prof. Dr. Matthias Bürgi
- **Economics and Social Sciences** – Prof. Dr. Irmi Seidl
- **Mountain Hydrology and Mass Movements** – Dr. Manfred Stähli
- **Alpine Environment and Natural Hazards** – Dr. Nadine Salzmann
- **Snow Avalanches and Prevention** – Prof. Dr. Jürg Schweizer
- **Snow and Atmosphere** – Dr. Martin Schneebeli

Planning and Logistics

Dr. Christoph Hegg

- **Human Resources** – Susanne Jost
- **Finances and Support** – Ludwig Stecher
- **Computer and IT Services** – Stephan Röthlisberger
- **Management of Facilities Birmensdorf** – Herbert Kurmann
- **Management of Facilities Davos** – Marco Collet
- **Lib4RI: Library Eawag, Empa, PSI, WSL** – Dr. Lothar Nunnenmacher

Programs and Centers

SwissForestLab
Prof. Dr. Arthur Gessler

Climate Change Impacts on Alpine Mass Movements
Dr. Michael Bründl

EnviDat
Dr. Gian-Kasper Plattner

Extremes
Prof. Dr. Niklaus Zimmermann

Blue-Green Biodiversity
Prof. Catherine Graham

National Forest Inventory NFI
Martin Hägeli

Long-term Forest Ecosystem Research LWF
Prof. Dr. Arthur Gessler

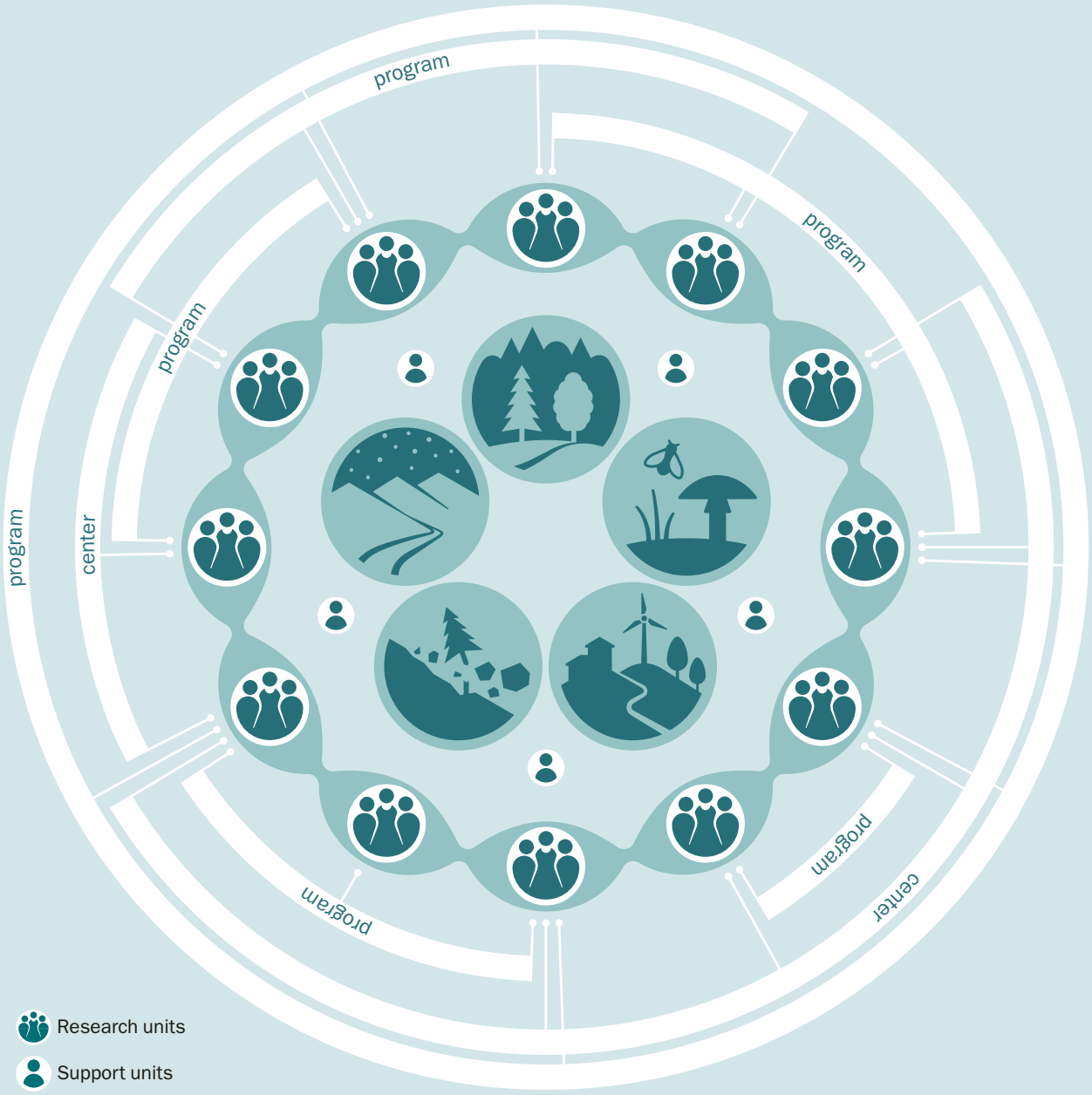
Climate Change, Extremes and Natural Hazards in Alpine Regions Research Centre CERC
Dr. Peter Bebi

WSL Biodiversity Center
Prof. Dr. Catherine Graham

WSL Landscape Centre
Dr. Silvia Tobias

Locations

Birmensdorf	Davos, SLF	Lausanne	Cadenazzo	Sion
Headquarters	Prof. Dr. Jürg Schweizer	Prof. Dr. Charlotte Grossiord	Dr. Marco Conedera	Dr. Pierre Huguenin



Conceptual view of how WSL is organized (the number of units, programs and centers is not representative). The five core thematic areas of WSL are forest, biodiversity, landscape, natural hazards, and snow and ice (see Section 5 in SAR Volume 1). Research units are structured according to the disciplines they cover, and they address one or several thematic areas of WSL. Support units provide technical services and infrastructure to WSL. Programs address relevant topics in an interdisciplinary manner across the institution. Centers are platforms pooling knowledge from across WSL and providing interfaces with stakeholders and practitioners. Programs and centers are fed by the scientific contributions of the research units.

Legend for facts and figures

Reference date for personnel: 31 December 2021

Personnel 2021

XY

Number of employees in full-time equivalents

XY %

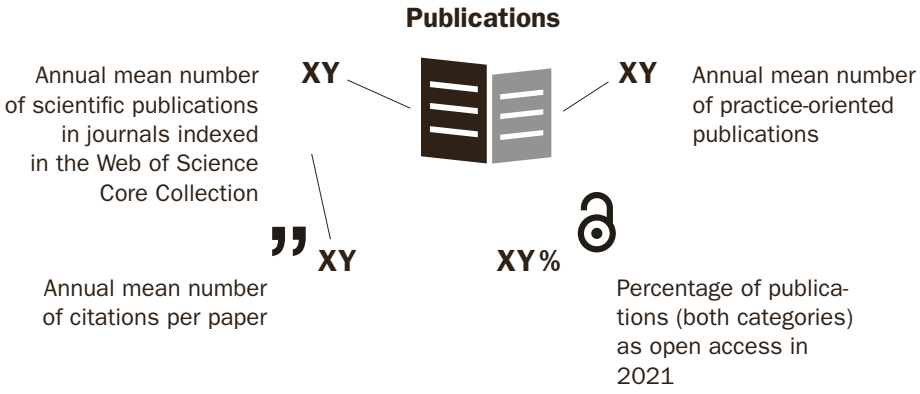
Percentage of personnel financed by third-party funds

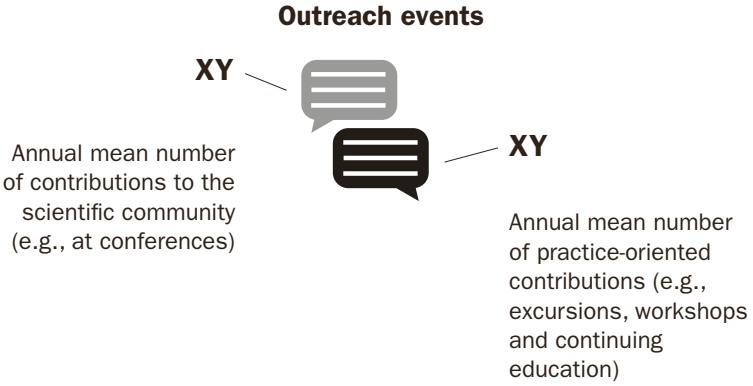
Research units

Scientific indicators

Annual mean between 2017 and 2021, except for the following units created later than 2017:

- Research unit Forest Health and Biotic Interactions (2018–2021)
- Research unit Alpine Environment and Natural Hazards (2021)





Teaching and student supervision

Annual mean number of hours taught at the two Swiss federal universities (ETH Zurich, EPFL), at cantonal universities, at Swiss universities of applied sciences, and at tertiary-level institutions abroad

XYX

X

Annual mean number of PhD theses supervised by WSL employees

X

Annual mean number of other theses (master's or bachelor's degrees and diplomas) supervised by WSL employees

Support units

List of main services provided by support unit

Programs and Centers

The main thematic areas addressed in programs and centers are represented by dark pictograms

Research units involved in programs and centers are highlighted

Research unit

wsl.ch/forest-resources

Forest Resources and Management

Aims and scope

The Forest Resources and Management research unit promotes evidence-based, sustainable use of forests and climate-smart forest management in the 21th century. Its mission is to build knowledge on Swiss forests for science, sustainable management, and people. While the focus is primarily on Switzerland, the unit is also very active at the international level. Specifically, research is directed to advance the understanding of the status, changes, responses and feedbacks of forests to global change. Long-term inventorying and monitoring networks, experiments, analysis and modeling all serve this purpose. Based on the findings from these activities, science-driven solutions are identified for sustainable forestry, provision of forest products and services, regeneration, and protection of biodiversity. In order to support applied forest management, these solutions are then implemented, for example in decision support systems, apps and outreach activities to administrations, enterprises and the broader public.

National tasks covered by the research unit include administering and contributing to the implementation of the Swiss National Forest Inventory (NFI) and Forest Reserve Research. The unit is also responsible for multiple research networks (e.g., Experimental Forest Management and Experimental Plantations) and for the administration of large national data portals (Virtual Data Center [VDC] and Datacenter Nature and Landscape [DNL]). Finally, the unit provides scientific support to federal and cantonal authorities.

At the international level, the research unit contributes to Switzerland's obligations under the Paris Agreement and UNFCCC regarding international reporting (Forest Europe and FAO), leadership (ICP Forests) and coordination (ENFIN). Due to this engagement and positioning, the unit has been successful in securing funding through internationally competitive research funding programs, such as Horizon Europe.

Facts and figures

Personnel 2021

57
full-time equivalents

56 %
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

52
scientific publications

55
practice-oriented publications

21
citations per paper

68 %
open access 2021

Outreach events

47
scientific contributions

43
practice-oriented contributions

Teaching and student supervision

307
teaching hours

7
PhD students

8
master's/bachelor's students

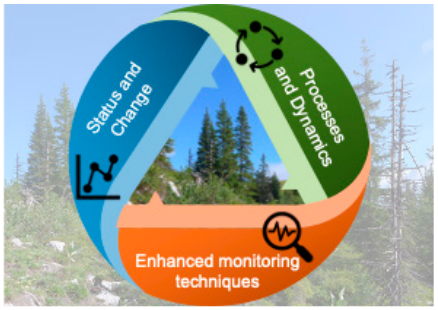
Major achievements since 2019

Experimental plantations

To provide practical guidance for tree species selection in a changing climate, a network of 59 experimental plantations of 18 tree species is being established throughout Switzerland as a joint effort involving WSL, FOEN, cantonal forest services, forest enterprises and forest owners. The site-specific performance of tree species and provenances will be monitored for 30–50 years in this Experimental Plantation network.

wsl.ch/experimental-plantations

Future monitoring of forests



The research initiative Advanced Inventorying and Monitoring for Swiss Forests (SwissAIM) aims to render existing monitoring infrastructures more dynamic and responsive to current and predicted environmental challenges. Several WSL research units, programs and centers are involved in its design. It is being developed with the support of the Swiss NFI and WSL.

wsl.ch/swissAIM

Decision support systems and tools

A suite of continuously updated tools that have been developed for diverse users are also relevant for outreach. Recent examples include TreeAPP, an interactive app providing tree species recommendations in Switzerland based on site types, climate drivers and expected shifts in vegetation height. Third-party funding includes FOEN, SNSF, ETH Zurich and the Wald- und Holzforschungsförderung Schweiz (WHFF-CH).

wsl.ch/forest-resources-tools

Virtual Data Center

The Virtual Data Center (VDC) is a web application pooling species data available in distributed databases (e.g., federal government, Cantons and parks), thereby facilitating analyses (e.g., environmental impact assessments). VDC is a project conducted in collaboration with and funded by FOEN.

wsl.ch/vdc_expert (login required)

Research unit

Forest Dynamics

wsl.ch/forest-dynamics

Aims and scope

The Forest Dynamics research unit studies past, ongoing and projected changes in forest composition, patterns and processes to generate science-based knowledge on the functioning of forest ecosystems and to advance concepts for sustainable forest management. One focus is ecosystem resilience to biotic and abiotic stressors and disturbances, while a second is the reconstruction of past variability in environmental conditions and the growth of trees and forests.

The key activities of the research unit are embedded in national and international legal mandates. There is, for instance, intensive engagement in the Long-term Forest Ecosystem Research program (LWF), as the Swiss contribution to ICP forests. Generally, the research activities of this unit create a methodological link between long-term monitoring, field surveys, reconstructions of past environmental conditions, short- and long-term manipulative and common-garden experiments, and modeling. Research covers different temporal and spatial scales, from seconds to millennia and from cells to ecosystems.

With experience in inter- and transdisciplinary research, this research unit fosters excellent research in both basic and applied settings, as well as outreach. For example, summer schools and training courses, such as the European Dendroecological Fieldweek, the International Course on Wood Anatomy and Tree-Ring Ecology, and the Summer School of the Nancy-Freiburg-Zurich forest research network, are met with great interest. The unit plays an active role in the scientific community, as demonstrated by the 17 editor roles in leading Web of Science journals and the production of edited textbooks. Moreover, the unit has a strong representation in scientific networks, such as the Integrated European Long-Term Ecosystem, critical zone and socio-ecological Research network (eLTER), the Integrated Carbon Observation System (ICOS), and the European Geosciences Union (EGU).

Facts and figures

Personnel 2021

52
full-time equivalents

34%
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

136
scientific publications

44
practice-oriented publications

22
citations per paper

73%
open access 2021

Outreach events

39
scientific contributions

21
practice-oriented contributions

Teaching and student supervision

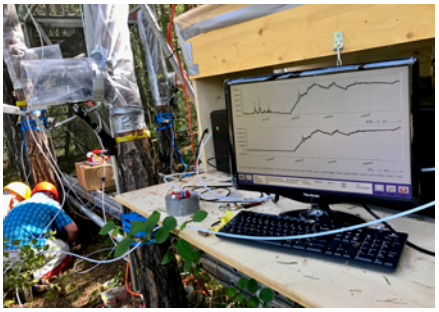
389
teaching hours

17
PhD students

13
master's/bachelor's students

Major achievements since 2019

Irrigation experiment at Pfynwald



The Pfynwald research platform is a unique long-term irrigation experiment used to study forest performance under varying water availability. A full-tree $^{13}CO_2$ pulse-chase study was recently conducted to analyze C sequestration dynamics and the connectivity between plants. This collaboration involving 10 European research groups was funded by SNSF.

wsl.ch/experiment-pfynwald | doi.org/10.1073/pnas.2014084117

Lötschental synthesis

The Lötschental transect in the canton of Valais, intiated in 2007, produces the world's longest time series of high-resolution cambium activity. Drought effects on wood structure, carbon sequestration and water use in trees are investigated at the cellular level, providing important information for forest modeling. The project is funded by SNSF.

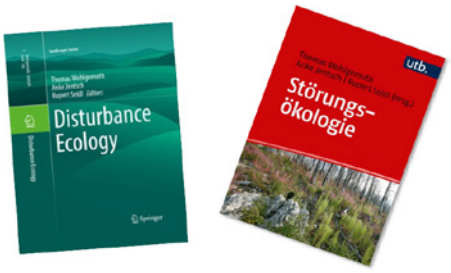
wsl.ch/loetschental-en

Dendroecological Fieldweek

Every year, the research unit runs and contributes to several summer schools, including the European Dendroecological Field Week. This field and lab course about tree-ring research covers a wide range of topics, such as climatology, ecology and archaeology. The course was initiated by WSL and is organized yearly in different countries by WSL and local partners.

wsl.ch/dendrofieldweek

Book on disturbance ecology



The research unit maintains diverse portfolios for knowledge transfer, including books, leaflets and policy briefs. The book Disturbance Ecology, which will be published in 2023, provides an overview of drivers and impacts of important disturbance agents across different ecosystem types, including forests, integrating issues of global change and disturbance management. The book is also available in German.

link.springer.com/book/9783030987558

Research unit

Forest Soils and Biogeochemistry

wsl.ch/forest-soils

Aims and scope

The Forest Soils and Biogeochemistry research unit investigates soil properties, processes and associated above- and belowground biogeochemical cycles, focusing on ecosystem functions and impacts of environmental change and land management. This work ranges from the micro scale (e.g., pathways and processes in the rhizosphere) to the national scale (e.g., inventories and maps of forest soil properties).

As part of the Long-term Forest Ecosystem Research program (LWF), the unit continuously records soil water chemistry, soil water balance, element deposition and tree nutrient status in a large variety of stands across Switzerland. Based on an in-depth understanding of site science, the relationship between soil properties and changing environmental conditions is studied, in addition to investigations of tree growth and nutrient status. Further, on a defined grid in Swiss forests, the change in forest soil properties 30 years after an initial survey is currently being investigated. Specifically, the impact of environmental changes on carbon, water and nutrient fluxes and pools is being assessed through stable and radioactive isotopes. To complete the picture, the unit uses biochemical and molecular methods to study interactions between soil, roots, microbes and soil fauna in natural systems. In addition to investigating the role of bacterial and fungal communities as drivers of biogeochemical processes, the group studies their genetic potential as indicators of environmental stress, focusing on alpine and Arctic soils and permafrost.

The research unit works together with national government offices, such as FOEN, as well as national and international universities, such as ETH Zurich, the Universities of Zurich, Bern and Pretoria, and the Imperial College of London. Funding comes from FOEN, SNSF, the Göhner Foundation, and international bodies, such as the European Commission, the German Research Foundation, and the Austrian Science Fund.

Facts and figures

Personnel 2021

31
full-time equivalents

19%
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

41
scientific publications

18
practice-oriented publications

21
citations per paper

76%
open access 2021

Outreach events

25
scientific contributions

8
practice-oriented contributions

Teaching and student supervision

348
teaching hours

8
PhD students

7
master's/bachelor's students

Major achievements since 2019

Swiss forest soil inventory

In coordination with the European ICP Forests program, a resampling of the chemical and physical properties of Swiss forest soils on a representative 8 × 8 km grid was started 30 years after the first sampling. A total of about 200 forest soil profiles are to be re-analysed.

wsl.ch/forest-soil-inventory

Carbon dynamics in forest soils

Recent technological advances have greatly enhanced the capacity for radiocarbon (^{14}C) measurement. In combination with the techniques used to measure stable ^{13}C, these approaches help to better assess the dynamics of C storage in forest soils and to support the Swiss greenhouse gas inventory and Kyoto Protocol.

wsl.ch/forest-soil-carbon

Quantifying soil water in forests

Soil water is essential for plants and soil biota and results from the interaction of climate, site conditions and vegetation. At 16 sites throughout Switzerland, measurements of soil water content and potential are used to assess soil water conditions in forests and to model future drought scenarios.

wsl.ch/forest-soil-water

Microorganisms in cold soils

Cold soils, such as permafrost, harbor a high diversity of microorganisms and viruses, with up to 1000 different species, and might serve as a refuge for ancient microbial life. Very little is known about their functional diversity and metabolic capability. This topic is being researched at sites in the Alps and the Arctic through international collaborative projects.

wsl.ch/cold-soil-microorganism

Research unit

wsl.ch/forest-health

Forest Health and Biotic Interactions

Aims and scope

The Forest Health and Biotic Interactions research unit carries out basic and applied research on the effects of insects and microorganisms on forest and urban tree health. This includes studies on interactions with climatic and other environmental factors (e.g., drought and anthropogenic disturbances) and with forest biodiversity. In addition, the unit hosts Switzerland's competence center for forest protection and is responsible for completing national tasks regarding monitoring and diagnostics of forest pests and pathogens and for providing scientific advice to Swiss authorities and the forestry sector. It operates state-of-the-art plant protection facilities (laboratories and greenhouses) with high biosafety levels to analyse microbiology, molecular biology, chemical ecology and environmental DNA.

The unit's main focus areas are: (1) investigations of native and non-native tree pathogens and insect pests under changing environmental conditions, along with the development of mitigation and control methods such as biological control and tree resistance; (2) the provision of specialist advice about pests and pathogens, surveillance activities, and diagnostic services for which the unit regularly develops and implements new diagnostic tools; and (3) the consequences of global change for biodiversity and species interactions involving forest insects and microorganisms, to develop a mechanistic understanding of community processes and to improve forest management and conservation measures.

The unit has a large network of collaborations with research institutions (e.g., Agroscope, National Research Institute for Agriculture, Food and the Environment [INRAE], the US Department of Agriculture, and the Canadian Forest Service) and with schools and universities (e.g., ETH Zurich and the Universities of Bern, Padova, Freiburg, Göttingen, Ohio State and Okayama). The unit is engaged in extensive outreach and has major teaching responsibilities at ETH Zurich and other tertiary institutions.

Facts and figures

Personnel 2021

32
full-time equivalents

47 %
financed by third-party funds

Scientific indicators Annual mean 2018–2021*

Publications

42 scientific publications

46 practice-oriented publications

16 citations per paper

83 % open access 2021

Outreach events

30 scientific contributions

34 practice-oriented contributions

Teaching and student supervision

136 teaching hours

4 PhD students

6 master's/bachelor's students

*Research unit established in 2018

Major achievements since 2019

Research on ash dieback and the emerald ash borer

The ash dieback (ADB) epidemic and the spread of the emerald ash borer (EAB) constitute major threats to European ash trees. The unit's research provides essential information and guidelines for ash conservation. For instance, it has led to the discovery of ADB tolerance of some ash genotypes and potential cross-resistance against EAB. This research has been funded by SNSF, FOEN and the Swiss Cantons.

wsl.ch/ash-dieback-emerald-ash-borer | doi.org/10.3389/ffgc.2021.645920

Monitoring and diagnostics of pests and pathogens

Early detection is key for pest and disease management. The unit has implemented advanced national monitoring, surveillance and diagnostics programs to detect new pests and diseases and to assist stakeholders via outreach activities. These tasks fulfill national and international obligations. Funding is provided by FOEN and the Swiss Cantons.

bit.ly/3QAWTMI

Biodiversity and resistance against global change pressures

Using trait-based approaches and analyses of stable isotopes and fatty acids, the unit studies changes in biodiversity (including trophic interactions and food webs) and in the functioning of forest ecosystems in response to management and climate change. For example, it was found that the biomass of non-native Douglas-fir is decomposed similarly to that of native trees, but by an impoverished decomposer community. SNSF, FOEN and the Blue-Green Biodiversity Research Initiative funded this work.

wsl.ch/biomass-douglas-fir

International collaborations on invasive species

The unit is strongly involved in collaborations on invasive forest pests and pathogens across Europe and beyond (e.g., Holistic Management of Emerging Forest Pests and Diseases HOMED). In this framework, the unit addresses aspects of forest biosecurity and biological control. Funding comes from FOEN, the EU and the Socio-Environmental Synthesis Center of the University of Maryland.

homed-project.eu

Research unit

wsl.ch/community-ecology

Community Ecology

Aims and scope

The Community Ecology research unit studies the physiological and ecological functioning of terrestrial ecosystems in the natural and built environment. This includes species interactions and species responses to their abiotic environment under ongoing global change. More specifically, the unit addresses issues associated with drought-induced disturbances, such as forest fires, heat stress and urban heat islands, with overfertilization, and with biodiversity loss in natural ecosystems. The increasingly important role of the atmospheric evaporative demand in these processes is considered. Research covers both forest and grassland ecosystems globally, ranging from high-elevation mountain areas to insubric, temperate, Mediterranean and tropical systems at lower elevations and in warmer regions.

The unit's strengths lie in instrumented experimental and observational research, conducted in cooperation with national and international partners and within broad internal and external networks. The work is conducted using novel tools developed by the unit (e.g., drones that can move within the tree canopy, thermal infrared systems, micro-computer tomography). As unit members are located in the three major language regions of Switzerland (German, French and Italian), they conduct extensive outreach. Specifically, the unit provides essential information to local managers, policy-makers, the media and the general public, communicating in the regional language. Moreover, the unit is strongly involved in disciplinary and interdisciplinary teaching at ETH Zurich and EPFL at the bachelor's, master's and PhD level. As a national task, the research unit manages the national forest fire database Swissfire, which was developed in a joint effort with FOEN and several cantons.

Facts and figures

Personnel 2021

22
full-time equivalents

27%
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

57 scientific publications

38 practice-oriented publications

26 citations per paper

62% open access 2021

Outreach events

31 scientific contributions

26 practice-oriented contributions

Teaching and student supervision

479 teaching hours

14 PhD students

19 master's/bachelor's students

Major achievements since 2019

Beech fire ecology

As a major outreach activity, research spanning 10 years has been summarized in a factsheet in German, French and Italian. In collaboration with the University of Turin, the research has been presented in a documentary video to inform forest managers about the fire ecology of Central European beech forests.

wsl.ch/beech-fire-ecology

Swiss National Park research

A book for the general public on the research conducted in the Swiss National Park over the last 20 years was published by the Research Council of the Swiss National Park in 2020. The book, highlighting the importance of food webs and nutrient cycles, is based on studies funded by SNSF and the Swiss National Park, which have resulted in over 20 publications indexed in Web of science. It is available in German.

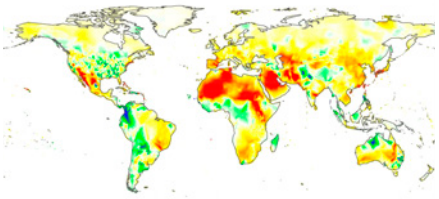
wsl.ch/nahrungsnetze-schweizer-nationalpark

Nutrient Network

The Nutrient Network was launched as an international collaboration project with over 100 partners and more than 130 grassland experimental sites worldwide. The aim of the network is to assess the impact of over-fertilization and the loss of large herbivores on grasslands.

nutnet.org

Vapor pressure deficit impacts on plants



Global warming is leading to a higher atmospheric evaporative demand, which has become the primary driver of tree mortality globally. This highly cited review paper on plant responses to rising vapor pressure deficit is the first to provide a fully integrated framework evaluating the effects on plant physiological functions in various global climate zones. It is first-authored by a WSL scientist.

doi.org/10.1111/nph.16485

Research unit

Biodiversity and Conservation Biology

wsl.ch/biodiversity-conservation

Aims and scope

The Biodiversity and Conservation Biology research unit studies the diversity of life at all levels: genes, species, traits, interactions and ecosystems. With partners from science and practice, including international, federal and cantonal authorities, the unit aims to deepen scientific knowledge to preserve natural resources and to cope with the biodiversity crisis, resulting primarily from climate change and habitat loss.

The research unit has two foci: (1) research to support the development of solutions to management issues concerning conservation and biodiversity, and (2) application and outreach targeted at conservation management, politics and society. Traditional tools (e.g., field surveys and experiments) are combined with state-of-art techniques (e.g., remote sensing, automated image analysis, genomics and environmental DNA) and social science approaches.

Key research topics are the coupled effects of climate change, human land use and pollution (e.g., microplastics) on biodiversity, as well as restoration and urban ecology. The unit's excellence in research is demonstrated by two recently received European Research Council grants and by its role in hosting a new joint research group from Eawag and WSL. In application and outreach, the unit enhances management strategies for biodiversity (e.g., integrative forestry, river restoration, adaptive management of grasslands and wetlands, and adaptation of trees to the changing climate), leads the new WSL Biodiversity Center, and evaluates the success of management interventions. In particular, the research unit carries out the long-term monitoring of the nationally important habitats of Switzerland and hosts the national data and information centers SwissLichens and SwissFungi. Members of the unit consult with stakeholders on practical issues, serve on advisory boards for authorities and organizations, and provide expert reports.

Projects are mainly funded through European programs, SNSF, FOEN, foundations for applied research, and the Swiss Cantons.

Facts and figures

Personnel 2021

52
full-time equivalents

60%
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

88
scientific publications

80
practice-oriented publications

18
citations per paper

69%
open access 2021

Outreach events

62
scientific contributions

46
practice-oriented contributions

Teaching and student supervision

519
teaching hours

15
PhD students

16
master's/bachelor's students

Major achievements since 2019

Trends in aquatic insect species richness

Data on Swiss aquatic insects collected at 438 sites from 2010 to 2019 indicated no insect decline. The species richness of aquatic insects remained stable or increased over time: warm-adapted species increased in richness and the richness of cold-adapted species was stable. This research was funded by the Blue-Green Biodiversity 2020 initiative.

doi.org/10.1098/rsbl.2021.0513

Adaptation of stone pine to climate change

Research financed by SNSF on 3000 genes in young and adult Swiss stone pines – a species that often forms the timberline – revealed that young trees at low elevations throughout Switzerland mostly have gene variants that are disadvantageous in a warmer and drier climate. Such an adaptational lag is problematic for species with long generation times and can lead to local extinctions.

doi.org/10.1111/gcb.15469

Red Lists of species and habitats

The unit contributes to several (inter)national Red Lists documenting the status of biodiversity, e.g., the national Red Lists for fungi and lichens funded by FOEN. Monitoring is based on field surveys by professionals and citizen scientists. To account for inconspicuous species, metabarcoding of fungal spores from air and deadwood and detectability analyses for lichens are applied.

swissfungi.wsl.ch | swisslichens.wsl.ch

Better Gardens: evidence-based outreach

The Better Gardens project, funded by SNSF, provided scientific evidence on the ecological and human benefits of urban gardens. They were found to harbor a remarkable number of species, and their biodiversity was directly linked with the perceived relaxation by gardeners. The project indicated that densification in urban areas is the main cause of biodiversity loss and ecological functions.

wsl.ch/bettergardens

Research unit

Land Change Science

wsl.ch/land-change

Aims and scope

Landscapes change over time, shaped by natural processes, such as erosion and succession, and by anthropogenic influences, such as agriculture, forestry and construction activities – in short, by land use. The Land Change Science research unit investigates this interplay through three lines of action. First, it conceives landscapes as expressions of the interrelationship between societies and their natural environment. From this perspective, the landscape scale serves as an integrative starting point for assessing the sustainability of natural resource use, leading to insights into leverage points for the transition towards sustainability. The second line of action includes analyses of past, present and future trends in landscapes, ecosystems and biodiversity patterns. In close collaboration with the Swiss authorities and the WSL research unit Economics and Social Sciences, the unit runs the Swiss Landscape Monitoring program LABES. In addition, researchers model spatio-temporal evolutionary and contemporary dynamics of ecosystems, species interactions, and migration processes from the regional to the global scale. Applied remote sensing and research for the public administration and the general public are at the core of the third line of action. As a partner in several projects, the unit assesses land cover inside and outside forests with remote sensing. For example, as part of the National Forest Inventory, information on forest ecosystems based on satellite, LiDAR and aerial imagery data is made available through the WSL environmental data portal EnviDat. Using remote sensing techniques and machine learning approaches, the research unit quantifies the status and development of national biotopes and supports agricultural monitoring.

The research unit is very active in international research networks (e.g., IPBES, ENFIN, International Association for Landscape Ecology [IALE]), collaborates closely with the main institutions and researchers in the respective fields, and co-designs projects with local to national authorities. The main funding sources are FOEN, SNSF, and EU funding schemes.

Facts and figures

Personnel 2021

46
full-time equivalents

55 %
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

119
scientific publications

42
practice-oriented publications

33
citations per paper

80 %
open access 2021

Outreach events

52
scientific contributions

11
practice-oriented contributions

Teaching and student supervision

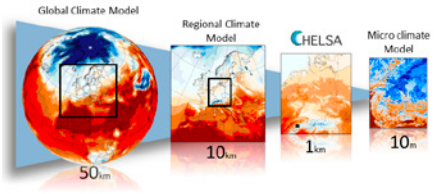
302
teaching hours

22
PhD students

21
master's/bachelor's students

Major achievements since 2019

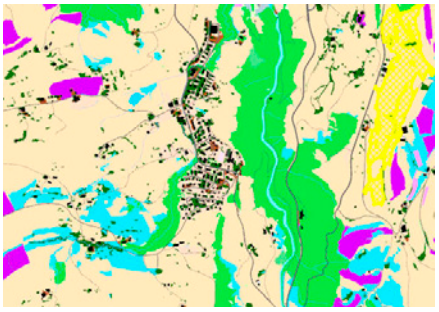
Climate mapping for climate change impact analyses



The CHELSA project (climatologies at high resolution for the earth's land surface areas) generated a suite of global climate and environmental maps from coarse-resolution input and downscaled them to obtain the resolutions required for regional to global applications. Map products are available at a resolution of 1 km globally and at the meter scale across Switzerland for microclimate.

wsl.ch/chelsa

Habitat Map of Switzerland



On behalf of and funded by the FOEN, the research unit developed and maintains a digital map of the distribution and spatial arrangement of habitat types across Switzerland. It builds on a variety of modeling and classification methods relying on earth observation data, and it serves as a key base data source for the planning of ecological infrastructure.

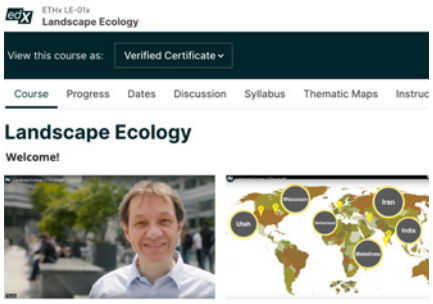
wsl.ch/habitat-map-switzerland

Governing urban regions: from plans to land change

In collaboration with international partners, the research unit developed and tested a theory explaining the effectiveness of spatial planning. This yielded new methods supporting plan evaluation studies and the integration of spatial policies into land change models. The approach was validated in Europe, North America, South America and China. Funding came from SNSF, Swiss Government Excellence Scholarships (ESKAS), and the China Scholarship Council (CSC).

wsl.ch/concur

First open online course in landscape ecology



Since 2018, more than 12,000 students worldwide have enjoyed this Massive Open Online Course (MOOC). Video lectures convey core principles of interdisciplinary landscape ecology through expert interviews, quizzes and interactive simulations. Applied case studies involving experts from Europe, India, Iran and North America give students a global learning experience. The MOOC is funded jointly by WSL and ETH Zurich.

wsl.ch/mooc

Research unit

wsl.ch/economics-social-sciences

Economics and Social Sciences

Aims and scope

The Economics and Social Sciences research unit explores societal, political and economic dimensions of WSL's research themes and develops comprehensive solutions in line with the planetary boundary concept. Specific research topics are identified and addressed through inter- and transdisciplinary cooperation with researchers in the natural and social sciences, as well as stakeholders. For instance, the unit considers climate change mitigation measures and adaptation by forest owners. A broad range of economic and social science concepts and methods are applied and further developed, such as those related to outdoor recreation, participatory planning, and financial compensation schemes.

Research in the unit is focused on the importance of biodiversity and natural resources for the economy; human health and quality of life in urban, peri-urban and rural areas; and the barriers to and opportunities for the implementation of policies in spatial planning, nature conservation and other areas. Beyond these foundational topics, researchers investigate societal values, demands and attitudes towards forests and landscapes, risk perception of natural hazards, governance of climate change adaptation, and societal monitoring with respect to forests and landscapes. Unique strengths of the unit lie in the research fields of climate change adaptation, landscape preferences, ecosystem service valuation, nature conservation policy, and participatory processes. Findings from these fields flow into societal discourse and teaching at universities.

Research partners are located in various European countries, though the majority are based at Swiss universities, ETH Domain institutions, universities of applied sciences, and private consultancies. Project partners and stakeholders range from federal to municipal administrations and from trade associations and NGOs to individuals of the broad public.

Facts and figures

Personnel 2021

17
full-time equivalents

42%
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

23
scientific publications

34
practice-oriented publications

12
citations per paper

75%
open access 2021

Outreach events

41
scientific contributions

28
practice-oriented contributions

Teaching and student supervision

200
teaching hours

12
PhD students

12
master's/bachelor's students

Major achievements since 2019

Integrated societal monitoring of forests and landscapes

The monitoring programs on forests and society (WaMos) and landscapes (LABES), financed by the national and cantonal administrations, combine spatial-physical and societal survey data in integrated models. This innovative approach has led to numerous scientific and outreach publications and to the establishment of "forest recreation" as a permanent module of the Swiss National Forest Inventory.

wsl.ch/wamos3 | wsl.ch/wml | wsl.ch/labes-en

Mainstreaming forest ecosystem services

The forest sector is challenged by the increasing societal demand for ecosystem services. Relevant tradeoffs, synergies and values were determined and the results were synthesized and specifically disseminated, supporting the mainstreaming of forest ecosystem services in public and private decision-making. Raising awareness, defining policy goals, and developing instruments were integral components.

nfp73.ch/en/projects/trade-offs-in-forests

Biodiversity-damaging subsidies in Switzerland

In collaboration with the Swiss Academy of Sciences, the project team identified 162 biodiversity-damaging subsidies and made suggestions on how they could be reformed. The report has triggered more than 30 interpellations in the national parliament and 8 in the Cantons. Federal offices now prioritize work on the topic. A web-app makes it possible to search for specific subsidies and related information.

subventionen.wsl.ch

Governance of climate change adaptation

An interactive website was developed by the unit to visualize the governance of climate change adaptation in all Alpine countries. It shows actors, adaptation activities, and knowledge resources (e.g., studies and reports). Four national environmental agencies collaborated, along with stakeholders from these and another three neighboring countries.

wsl.ch/gov-vis-cca

Research unit

wsl.ch/mountain-hydrology

Mountain Hydrology and Mass Movements

Aims and scope

The Mountain Hydrology and Mass Movements research unit studies hydrological, glaciological and natural hazard processes in predominantly mountainous, glacierized, and partially forested regions. Researchers assess damage and damage processes of frequent to rare and extreme natural events, as well as glacier dynamics and their impacts on water resources, landscape evolution and ecosystems, considering a wide range of spatial and temporal scales. In particular, they investigate the formation and propagation of flood flows, bedload transport, landslides and debris flows, as well as the occurrence of hydrological droughts. Both experiments and long-term measurements form the basis for the development and application of numerical models, environmental sensor prototypes, and hazard assessment methods. The collected data is used for risk-based, sustainable management of natural hazards and water resources.

Current projects address pressing societal challenges, such as the early detection and warning of drought, debris-flow and landslide events, and the impacts of climate change on torrents, lake levels and hydrological extremes. Other projects concern the impact of regional and global glacier loss on downstream regions, ecosystems and water users, which is relevant for sustainable hydropower production in the context of the energy transition. Competence is available on the optimization of hydrological forecasts for improved management of flood events.

To this end, the research unit collaborates with other institutions of the ETH domain and national and international research institutions, as well as with government agencies, cantonal and municipal authorities, private sector companies, and NGOs. A significant contribution is made to (inter)national expert networks and to the further education of professionals in the domains of natural hazards and water resource management.

Facts and figures

Personnel 2021

38
full-time equivalents

53 %
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

65
scientific publications

30
practice-oriented publications

22
citations per paper

81 %
open access 2021

Outreach events

55
scientific contributions

11
practice-oriented contributions

Teaching and student supervision

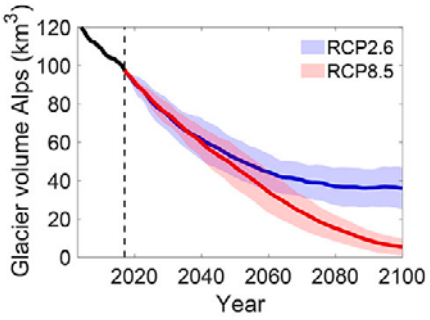
172
teaching hours

20
PhD students

20
master's/bachelor's students

Major achievements since 2019

Glacier and hydrological scenarios for Switzerland



To estimate the impact of climate change on hydropower production, lake levels and agricultural irrigation demand by the end of the century, the expected changes in glacier mass and water resources in Switzerland have been calculated based on the CH2018 scenarios. The resulting hydrological and glacier scenarios are provided to other researchers and stakeholders in the energy sector.

wsl.ch/nccs-schweizer-hydroszenarien

Debris-flow observatory

The debris-flow force plate in Illgraben was completely rebuilt in 2019. Along the channel, an array of novel high-resolution LiDAR sensors have been set up, providing unique insights into the composition of destructive flows. A recent machine-learning-based method using seismometric data has significantly improved the early detection of imminent debris flows.

doi.org/10.1029/2020GL090874

First WSL spin-off

In 2021 the unit launched the first-ever WSL spin-off company, TerraRad Tech, which develops and sells drone-based remote sensing instruments for soil-wetness measurements, smart farming, wildfire detection, and glacier monitoring. The new firm is the result of many years of L-band microwave research in collaboration with ESA and the Soil Moisture and Ocean Salinity (SMOS) satellite community.

wsl.ch/news/wsl-spin-off

Analysis of the severe drought of summer 2018

After the Europe-wide drought event of 2018, the unit launched a comprehensive WSL research initiative to assess the drought's hydrological and forest-related impacts. These findings, as well as the drought information platform *www.drought.ch* run by the unit, were an essential source of information for managing the prevailing severe drought situation of summer 2022 in Switzerland.

wsl.ch/drought2018

Research unit

wsl.ch/alpine-environment

Alpine Environment and Natural Hazards

Aims and scope

The Alpine Environment and Natural Hazards research unit aims to assess and understand the effects of climate change and extreme events on physical and ecological processes in mountain environments, related natural hazards, and emerging new risks for society. This includes the identification and assessment of key impacts, changing processes and compound system interactions. The specific thematic scope and core expertise of the unit comprises mountain permafrost, alpine mass movements, mountain ecosystems, and alpine remote sensing. Inter- and transdisciplinary research is fostered with other units at WSL and with national and international scientists and research institutions.

A wide range of methods and approaches is applied to achieve the above goals. The unit uses cutting-edge measurement devices, sensors (e.g., LiDAR, thermal and multispectral) and processing technology, and it develops prototypes and tailored techniques (e.g., for satellites, drones and ground-based systems). Approaches include long-term monitoring systems (permafrost and biodiversity), small- to large-scale field experiments (e.g., rockfall combined with protection forest), and numerical models for science and practice (e.g., RAMMS). To generate plausible scenarios for the future evolution of the Alpine environment, these models are linked to tailored data series of climate and extreme weather.

This unit was formed in July 2021 within the establishment of CERC. It covers four of CERC's six thematic topics. In the framework of CERC, the unit collaborates with cantonal, national and international partners, such as the Department of Forests and Natural Hazards (AWN, Canton Grisons), Geobrugg, the Swiss Agency for Development and Cooperation (SDC), and UNFCCC to translate research results and to implement them in practice.

Facts and figures

Personnel 2021

25
full-time equivalents

40 %
financed by third-party funds

Scientific indicators 2021*

Publications

9 scientific publications

6 practice-oriented publications

1 citations per paper

64 % open access 2021

Outreach events

25 scientific contributions

19 practice-oriented contributions

Teaching and student supervision

53 teaching hours

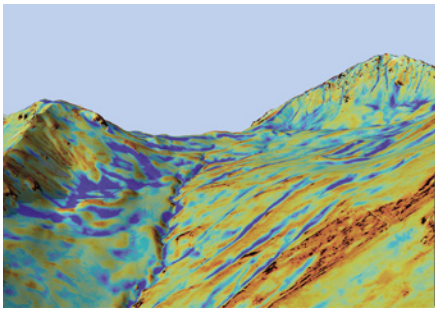
4 PhD students

11 master's/bachelor's students

*Research unit established in 2021

Major achievements since 2019

Snow depth mapping to plan protection measures



To plan avalanche mitigation measures and to assess their effect, the distribution of snow depth in high alpine terrain is accurately mapped using drones and airplanes. In collaboration with cantonal and local authorities, the unit established a methodology in which snow-free digital surface models are subtracted from snow-covered ones derived using photogrammetry.

wsl.ch/snow-depth-drones

Simulation of rock and ice avalanches

Recent natural disasters (Piz Cengalo and Chamoli) highlighted the need to understand how rock and ice avalanches transform into dangerous debris-type floods. The unit developed a model that accounts for melting ice, solid–fluid flow transitions, and the entrainment of highly saturated deposits. The model is now widely used, for instance in collaboration with SDC, UNDP and UNESCO.

wsl.ch/ramms-en

Cold regions biodiversity in a changing climate

Building on experience in the long-term monitoring of plant species changes in mountain regions, the unit has extended this work to more integrative ecosystem research, including animal biodiversity, belowground–aboveground interactions, and elevation gradients across treelines. Further, activities with regional agencies (e.g., 100 years of flora change in Grisons) have been strengthened.

wsl.ch/biodiversity-mountain-plants

Long-term permafrost monitoring

The unit maintains a long-term climate-related monitoring network for permafrost in the Swiss Alps and contributes to the Swiss Permafrost Monitoring Network (PERMOS) and the Global Terrestrial Network for Permafrost (GTN-P). Permafrost status, including ground temperature and rock glacier velocity, is defined as an essential climate variable by the UNFCCC.

wsl.ch/permafrost-monitoring

Research unit

wsl.ch/snow-avalanche

Snow Avalanches and Prevention

Aims and scope

The Snow Avalanches and Prevention research unit investigates the formation and dynamics of avalanches to better predict the location, timing and impact of avalanche events. Based on laboratory experiments and field investigations, process models are developed to describe, for instance, fracture processes leading to dry-snow slab avalanches. At the unique test site Vallée de la Sionne, very large avalanches are triggered artificially to measure flow dynamics. These measurements form the basis for improving avalanche dynamics calculation methods, such as the Rapid Mass Movement Simulation software (RAMMS).

Climate change is expected to alter the frequency and spatial occurrence of natural hazards. To assess the corresponding changes in risk, socio-economic factors must also be incorporated, such as changes in population size and distribution, use of transportation routes and other infrastructure. To this end, the unit develops innovative methods and tools to improve risk management procedures. This in turn equips practitioners with robust solutions for climate change adaptation, rendering society more resilient.

The research unit operates the Swiss avalanche warning service on behalf of the Swiss government. Twice daily, it issues the avalanche bulletin informing the public about the current snow situation and avalanche danger. The unit additionally develops software and runs warning and information systems for authorities and local safety services. For the public, the avalanche prevention portal WhiteRisk is provided.

In the Swiss Alps and abroad, the unit provides advice on snow and avalanche engineering problems and risk management. Great emphasis is placed on the continuous translation of the latest research and development findings into practice and their inclusion in teaching, training and consulting activities.

Facts and figures

Personnel 2021

47
full-time equivalents

40 %
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

23
scientific publications

25
practice-oriented publications

12
citations per paper

69 %
open access 2021

Outreach events

25
scientific contributions

41
practice-oriented contributions

Teaching and student supervision

73
teaching hours

13
PhD students

8
master's/bachelor's students

Major achievements since 2019

Dynamic crack propagation in weak snowpack layers

Dynamic crack propagation in weak snowpack layers is a fundamental process affecting avalanche release size. With novel experimental and numerical methods, two SNSF-funded PhD students in this unit demonstrated the great importance of crack propagation speed and suggested new formulations to estimate crack speed from snowpack properties.

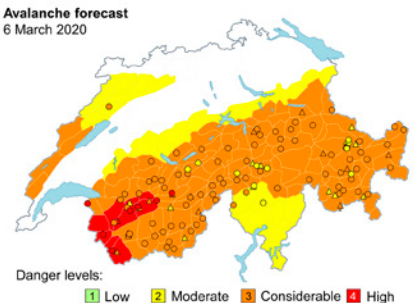
wsl.ch/fracture-propagation

A new method for calculating avalanche impact pressure

The pressure that snow avalanches can exert on infrastructure, such as houses and cable car pylons, is a central issue in avalanche research. In the context of an SNSF-financed project, the unit developed an improved physics-based calculation method able to consider different flow types and structure geometries.

wsl.ch/calculating-avalanche-pressure

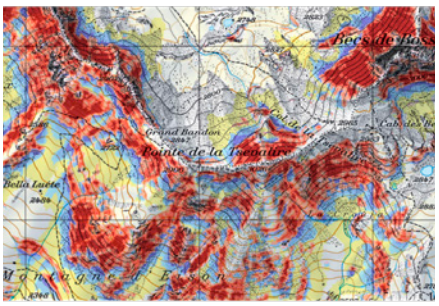
Data-driven automated predictions for avalanche forecasting



Using measured meteorological and simulated snow cover data from weather stations, a machine learning algorithm predicting the avalanche danger level was developed in collaboration with the Swiss Data Science Center (SDSC). The avalanche warning service tested the model with promising results. Thus, the application of objective methods in avalanche warning is within sight.

wsl.ch/ai-avalanche-warning

Automatic mapping of avalanche terrain



In the context of a WSL internal project, a new method was developed for a high-resolution automatic classification of the avalanche terrain for recreational backcountry travel in winter. In collaboration with the Rapid Mass Movement Simulation (RAMMS) research group, two types of publicly available maps were created and integrated into the avalanche prevention portal WhiteRisk.

wsl.ch/avalanche-terrain-maps-en

Research unit

wsl.ch/snow-atmosphere

Snow and Atmosphere

Aims and scope

The Snow and Atmosphere research unit investigates the physical properties of snow and its exchange processes with the soil and atmosphere. The aim is to understand the formation of natural hazards, such as avalanches and floods, and the interactions between the cryosphere and climate change. To this end, the unit also studies the microstructure and metamorphism of snow. Nationally relevant products are delivered in snow hydrology and snow climatology, and as support for Swiss Olympic.

The research conducted by this unit is essential for understanding the changes in the interactions between the cryosphere and the earth system. Specifically, researchers study how climate change affects the roles of snow and wet or frozen ground in the formation of natural hazards, how they influence the earth's climate, and how the snow cover affects permafrost, sea ice and ice sheets in alpine and polar regions. Experimental research occurs at various field sites and in laboratories. Long-term observations, such as those made on Weissfluhjoch (Davos, 2536 m a.s.l.), provide ideal data for model calibration. Novel and in some cases patentable instrumentation is being developed to quantify snow properties.

Process understanding resulting from snow physics leads to improved numerical models applied in climate analysis and natural hazard warning systems. Models developed in the unit (SNOWPACK, Alpine3D, FSM2 and CRYOWRF) accurately simulate snow at multiple scales. These models provide operational data and products for stakeholders, such as FOEN, SLF's in-house avalanche warning service, and WMO.

The joint professorship with EPFL in the Laboratory of Cryospheric Sciences (CRYOS) engages in snow modeling and renewable energy in the Alps, specifically regarding photovoltaics and wind. The new joint professorship with ETH Zurich in Hydrology and Climate Impacts in Mountain Regions will focus on the influence of climate change on extreme events.

Facts and figures

Personnel 2021

30
full-time equivalents

38%
financed by third-party funds

Scientific indicators Annual mean 2017–2021

Publications

33
scientific publications

15
practice-oriented publications

22
citations per paper

81%
open access 2021

Outreach events

29
scientific contributions

13
practice-oriented contributions

Teaching and student supervision

119
teaching hours

12
PhD students

6
master's/bachelor's students

Major achievements since 2019

Snow and ice during the MOSAiC expedition

During the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) expedition, snow cover on Arctic sea ice was measured and quantified with instruments developed at SLF. For the first time, the snow and surface scattering layer was imaged with an X-ray micro-computer tomograph. The expedition was co-funded by the Swiss Polar Institute (SPI).

wsl.ch/blog-mosaic-en

Snow and solar power

Photovoltaic energy harvesting can profit from the intense solar radiation in the Alps and from the reflection of shortwave radiation by the snow cover. The research unit has shared knowledge on snow modeling and snow physics with industry start-ups, thereby improving the selection of installation sites and optimizing the orientation of the panels.

doi.org/10.1073/pnas.1720808116

Snow science winter school

The European Geosciences Union (EGU) Snow Science Winter School, offered jointly by SLF, the Finnish Meteorological Institute and Meteo France, is among the courses organized by this unit. In this school, advanced methods for measuring snow properties are taught. The school receives support from EGU and other institutions.

slf.ch/snow-science-winter-school

Multi-scale modeling of forest–snow processes

The development of novel measurement systems by researchers in this unit enabled the implementation of a hyper-resolution model. This model accurately represents forest–snow processes down to the scales of meters and minutes. The model is being used for both interdisciplinary research and operational applications.

wsl.ch/snow-forest

Support unit

Human Resources (HR)

wsl.ch/hr-en

Scope and tasks

To enable WSL to fulfill its mission and tasks, the HR support unit fosters the continuous shaping of a working environment in which qualified and personally committed employees can develop and advance their skills and knowledge. In cooperation with the Directorate, line management and employees, the HR unit develops appropriate instruments to support WSL's values and culture at all five sites: Birmensdorf, Davos, Cadenazzo, Lausanne and Sion (see Section 1 in SAR Volume 1).

HR services cover the entire HR lifecycle from entry to exit, including payroll and social security, as well as professional HR consulting. In this way, WSL's HR services meet the complex requirements for seamless HR administration, in terms of both quality and labor law. Transparent, reliable working conditions that support flexible forms of work are essential for WSL to be internationally competitive and to remain an attractive employer in all language regions of Switzerland. In the context of advising line managers, the HR unit provides support throughout the recruitment process, during annual appraisals, and in leadership issues. It evaluates and organizes training sessions and develops measures that ultimately support all employees, such as in-house leadership training workshops for group leaders. As part of its regular reporting the HR unit provides important key figures, thereby highlighting trends and allowing the Directorate to make targeted and informed decisions.

Lifelong learning, digitalization, leadership, health and the optimal balance between career and other areas of life are current topics requiring ongoing initiatives and projects. The HR unit carefully considers socially relevant developments, such as diversity and inclusion, social security and skills shortage, and it acts with an awareness of expected future trends. Within the framework of the applicable personnel law, the HR unit develops directives and guidelines in cooperation with the other institutions of the ETH Domain.

Facts and figures

Personnel 2021

8

full-time equivalents

- HR processes, directives and guidelines
- HR consulting and administration
- Personnel marketing and recruitment
- Remuneration and social security
- Training and development

Finance and Support

Support unit

wsl.ch/finance-support

Scope and tasks

The Finance and Support unit provides financial services, administrative support, and laboratory analysis services.

The first sub-unit is responsible for finance. It efficiently and prudently manages WSL's budget resources and implements accounting in accordance with the law. It supports researchers in the administration of third-party funds and is the point of contact for value-added tax and other accounting issues. The sub-unit takes care of the annual financial reporting, which is regularly checked by internal and external audits.

The second sub-unit provides administrative support in various areas. The in-house shop in Birmensdorf, for instance, produces high-quality documents and printed matter, manages office supplies, and organizes worldwide mailing. The reception staff often serves as the first point of contact for WSL, and it represents the interface between internal and external sides of the institute. As such, it handles central telephone traffic, manages guest accommodations, and coordinates courier service deliveries. Finally, the secretariat performs administrative tasks for research units, travel services and absence checks.

The central laboratory provides indispensable services to WSL researchers. These services range from planning, sample preparation and analysis to the evaluation of samples and measurements. Water, plant, soil and air samples are routinely analyzed for carbon, nutrients (e.g., nitrogen) and trace elements, as well as anions and ^{13}C, ^{15}N, ^{18}O and ^{2}H isotopes. On request, sugars, amino acids, nitrous oxide and other substances can be analyzed. The central laboratory carries out around 20,000 analyses per year for internal purposes. The excellent quality and traceability of the data makes WSL scientists coveted project partners, both nationally and internationally.

Facts and figures

Personnel 2021

21
full-time equivalents

- Financial management of projects
- Invoice receipts and payments
- Financial and administrative support
- Central laboratory services

Support unit

Computer and IT Services

wsl.ch/it-services

Scope and tasks

State-of-the-art information and telecommunication technologies are a crucial driver of top-level research. The Computer and IT Services unit is responsible for the provision of a high-quality IT infrastructure and modern electronic tools to scientists and research units, as well as to the other support units. As researchers also often demand the introduction of new IT technologies, the close collaboration of this unit with WSL researchers is key.

This support unit is responsible for the seamless operation of the entire information and communication infrastructure at WSL and SLF, and for the development, support and maintenance of various applications. The range of IT services includes provision of basic user support, procurement and installation of IT hardware and software, design and implementation of complex server installations, database maintenance, and management of a high-performance computing infrastructure with over 1200 central processing units. In particular, the unit handles the maintenance of the server infrastructure with application, file and backup systems, as well as the provision of email and collaboration platforms (e.g., Zoom and Microsoft Teams), internet and intranet portals, and user and technical support for all IT matters.

Another important and increasingly complex task of this support unit is IT security. In the interest of WSL, its employees and business partners, this support unit ensures that information is secured against loss, manipulation and unwanted publication.

To master the increasing complexity of IT field, to make best use of the limited resources at WSL, and to ensure access to the necessary expertise, this unit cooperates closely with colleagues within the ETH Domain and within the network of Swiss universities.

Facts and figures

Personnel 2021

17
full-time equivalents

- IT infrastructure
- User support
- Consulting
- Application development
- Hardware and software procurement
- IT security

Communication

Support unit

wsl.ch/communication

Scope and tasks

The Communication support unit is responsible for WSL's public relations. It uses channels such as websites, videos, social media, and the WSL magazine DIAGONAL to reach the public directly, while using media relations to broadcast science news through newspapers, TV and radio. The unit is responsible for organizing outreach activities, in the form of guided tours and public events, to meet the needs of specific audiences or stakeholder groups. The unit additionally plays a central role in internal communication channels such as the intranet and the staff newsletter. It supports researchers in their knowledge transfer activities through the production of publications and web-based tools for public authorities and the private sector.

In addition, the unit fulfills both strategy-supporting and service-oriented tasks. It serves as a first contact point for internal and external bodies to obtain technical and methodological support, e.g., in web publishing, editing, proofreading and layout. The unit gives communication advice to the WSL Directorate and all employees.

WSL attaches great importance to active, factual and open communication, both internally and externally. It should be transparent to the public what research is financed with tax money and how society benefits from science. This applies in particular to politicians, as representatives of the public, and to the media, an important interface between WSL and the public. To this end, the communication unit complies with the "Guidelines for Good Science PR" of the German Federal Association of University Communication. Finally, it attaches great importance to dialogue-based forms of communication in which researchers and practitioners or the public meet as equals, for example at the Forum für Wissen.

As all WSL researchers are responsible for good communication, the unit perceives itself very much as a supporter and enabler, as stated in WSL's communication strategy.

Facts and figures

Personnel 2021

15
full-time equivalents

- Public outreach
- Internal communication
- Knowledge transfer
- Consulting
- Communication support

Support unit

wsl.ch/facility-management-bi

Facility Management Birmensdorf

Scope and tasks

The Facility Management support unit in Birmensdorf provides services that are necessary for the smooth functioning of the infrastructure required for an optimal research environment. The main tasks include technical and infrastructural management of buildings at the Birmensdorf site, as well as operation and maintenance of its in-house staff restaurant. In addition, a facility for processing plastic and metal, as well as a carpentry workshop, support WSL research activities with structures and equipment developed specifically for the needs of individual projects. To ensure the mobility and flexibility of the researchers, a vehicle fleet with all-terrain vehicles, passenger cars and minibuses is available for the transport of people and equipment.

The experimental garden located on the WSL premises in Birmensdorf supports researchers in the field of seed and plant propagation. For example, seeds are harvested from all over Switzerland and processed for optimum germination. The seed material is stored in cold rooms under conditions that promote their long-term viability. This unit organizes seed and sapling material for forestry operations and offers advice in forestry-related areas, such as plant propagation.

In addition, this support unit is responsible for WSL's public procurement, real estate management, and energy and material reporting to the ETH Domain. For construction projects, the unit acts as the client's representative and, together with Empa, realizes WSL's renovation and new construction projects. Finally, the unit is responsible for operational safety, with a fire protection group, an evacuation organization, and a 24-hour on-call and first-aid service.

Facts and figures

Personnel 2021

19

full-time equivalents

- Technical and administrative support
- Catering
- Procurement
- Occupational safety
- Plant cultivation

Facility Management Davos

Support unit

wsl.ch/facility-management-da

Scope and tasks

The Facility Management support unit in Davos is responsible for the provision and smooth functioning of the infrastructure at SLF, as well as the provision of technical aid and installation assistance for numerous research projects. Hardly any of the equipment and experimental facilities required for field and laboratory experiments are available commercially as complete products. In many cases, these elements need to be specially developed, designed and manufactured in close cooperation between the Facility Management unit and the researchers. These include heavy metal structures, such as the debris-flow force plate in Illgraben and the test facility with a 20-m-tall measuring mast in Vallée de la Sionne, but also very small sensors, such as those measuring temperature in permafrost soils or acceleration in rockfall tests. This technical service includes maintaining automatic measurement networks, experimental facilities and cold laboratories for research on avalanche activity, debris flow behavior and snowpack properties.

The unit is additionally responsible for maintaining, adapting and modernizing the SLF buildings. Further, it runs and maintains the in-house cafeteria, where meals are provided for SLF staff. Finally, the unit maintains a vehicle fleet with all-terrain vehicles, passenger cars, minibuses and cable cars to transport staff and equipment.

The housekeeping, technical, cleaning and secretarial services are all affiliated with the Facility Management unit, as is the employee responsible for occupational safety.

Facts and figures

Personnel 2021

19
full-time equivalents

- Technical and administrative support
- Catering
- Real estate management
- Occupational safety

Support unit

lib4ri.ch

Library Lib4RI

Aims and scope

In 2011, a joint library was established for the four research institutes within the ETH Domain (Lib4RI). This library has often been referred to as an outstanding example of cooperation amongst the institutions of the ETH Domain. Its focus is on providing a comprehensive range of electronic media and web-based, customer-friendly services. Both are constantly being developed and adapted to meet changing user needs. As the transition from print to online media is almost complete, the main focus is now shifting towards service provision.

As a scientific library, Lib4RI provides the four research institutes, at 11 sites, with access to extensive literature and technical information for research, teaching and consulting purposes. The rapidly growing offer of e-journals and e-books has resulted in a quadrupling of usage since 2011. In 2021 alone almost one million full texts were downloaded.

Lib4RI further operates digital object repository DORA, a database offering a complete registry of the institutes' publications, ranging from indexed journal articles to outreach publications. As a service to researchers, data is harvested from several systems (e.g., Scopus, Web of Science and CrossRef) to make the publication records as complete as possible. DORA offers an assisted deposit service to make publications open access ("green road"). As a result, roughly 83% of the articles by WSL authors that were published in 2021 are open access, and more than 370,000 full text downloads of these articles were processed in 2021. Open access via DORA has thus significantly increased the visibility of WSL researchers and the institute.

Finally, the library has developed and offers training courses, mainly aimed at PhD students, which are met with considerable interest. The topics of the six modules cover searching scientific information, open access and copyright regulations, scientific publishing, and the document preparation system LaTeX.

Facts and figures

Personnel 2021

15
full-time equivalents

for the four research institutes

- Electronic media
- Complete bibliography
- Open access services and stewardship
- Consulting and training

Program

swissforestlab.wsl.ch

SwissForestLab

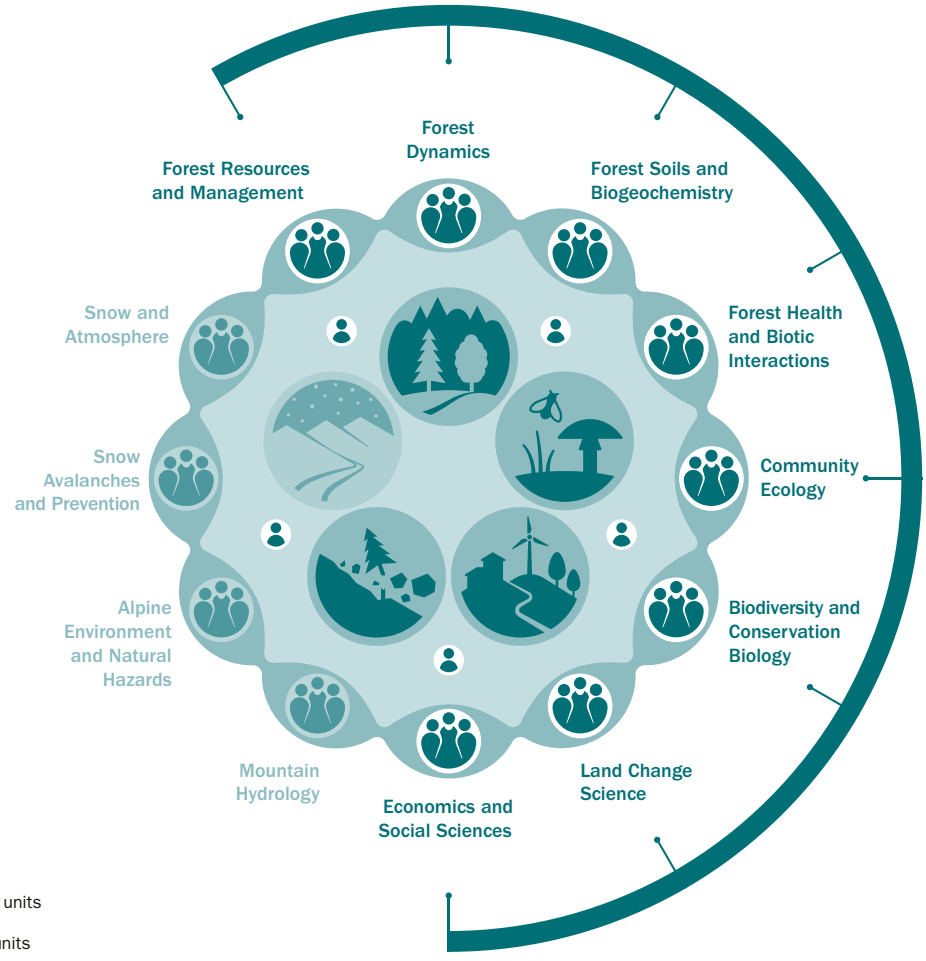
Aims and scope

The SwissForestLab, launched in 2017, is a joint endeavor of WSL, other Swiss research institutions, and Swiss universities working in the area of forestry. It aims to advance the understanding of the complexity and functioning of forest ecosystems and their sustainable use in a changing world.

The SwissForestLab research platform and infrastructural network helps scientists to assess the effects of a dynamically changing environment on forests. By integrating all relevant actors in Switzerland (including >120 WSL researchers), as well as their infrastructure, the SwissForestLab facilitates research synergies and scientific excellence in the field of ecosystem functioning, resistance and resilience. Apart from financially supporting joint research projects among its members, SwissForestLab stimulates transdisciplinary collaborations and translates novel findings into practice.

With its partners from practice, SwissForestLab organizes the one-day workshops "Dialogue with Practice" with different stakeholder groups. Together with representatives from FOEN, it conducts bi- and multilateral meetings to identify the needs in practice and to discuss new scientific findings directly with end-users. Moreover, outreach to broad audiences (e.g., students, public interested in climate change impacts, political decision-makers) is carried out via summer schools and web applications (e.g., through the National Centre for Climate Services [NCCS]).

The SwissForestLab focuses on the most pressing topics in forest research: (1) climate change effects on forest ecosystems, (2) biodiversity and ecosystem functioning, and (3) land-use change and its long-term legacy. To pursue these topics effectively, it collaborates with international partners such as the Albert-Ludwig University of Freiburg, INRAE Nancy, University of Melbourne, and University of Toronto.



Major achievements since 2019

Forest functions and climate change

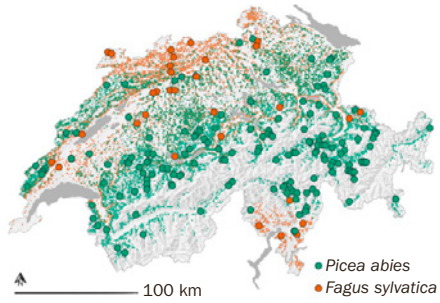
As a contribution to NCCS, SwissForestLab developed user-friendly information, in the form of personalized storylines, on climate change impacts on forests, targeting practitioners, the public and political decision-makers. In this activity, it collaborates with ETH Zurich, Agroscope and the Research Institute of Organic Agriculture (FiBL).

wsl.ch/nccs-forest-functions-climate-change

Research platform: scientific publications from joint projects

More than 25 scientific papers from SwissForestLab projects with international partners have been published and are listed in Web of Science. In a seminal paper, Trotsiuk et al. (2020) used model–data fusion to estimate the response of forest productivity in Switzerland to climate extremes using data from long-term monitoring and inventory plots (237 spruce and 34 beech plots).

doi.org/10.1111/gcb.15011



"Dialogue with Practice" workshops and summer schools

The SwissForestLab organizes regular workshops, Dialogue with Practice, for practitioners, decision-makers and scientists. For international student education, an annual summer school on forest research is conducted in Davos together with the Nancy-Freiburg-Zurich Forest Research Network (NFZforest.net) and ETH Zurich.

swissforestlab.wsl.ch/dialog2022 | *wsl.ch/swissforestlab/summer-school*

Infrastructure network: SwissForestLab metadatabase

The SwissForestLab maintains an extensive metadatabase on forest research infrastructure (e.g., canopy cranes), data and models in Switzerland. The database was developed in cooperation with EnviDat and is based on information provided by SwissForestLab members and their institutions. It makes forest research data accessible, thereby stimulating its cooperative scientific use.

Program

ccamm.slf.ch

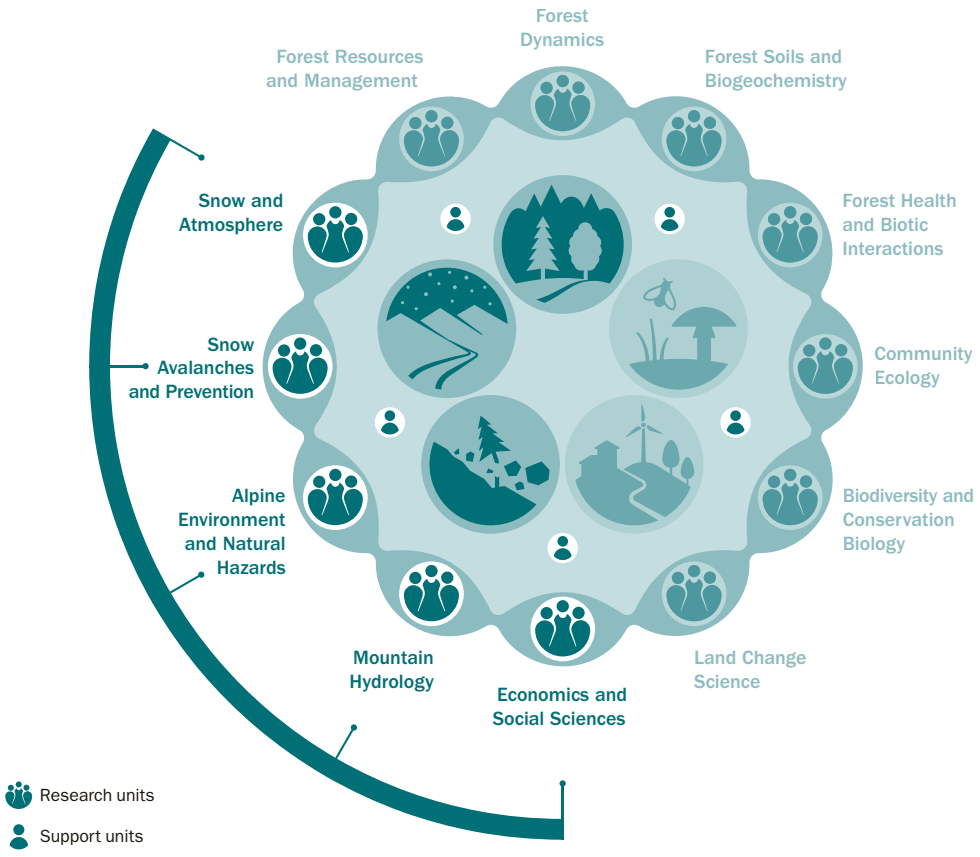
Climate Change Impacts on Alpine Mass Movements (CCAMM)

Aims and scope

WSL launched the CCAMM program to research mass movements and the impact of climate change in mountain areas. Observations of shrinking glaciers, thawing permafrost, and decreasing snow coverage reflect the sensitivity of high mountain regions to global warming. Further, expected changes in heavy precipitation will likely influence the frequency and magnitude of alpine mass movements such as rock slope failures, landslides and snow avalanches. Rising air temperatures will likely affect forest disturbances, such as windthrow, insect calamities and forest fires, undermining the functionality of protection forests.

CCAMM addresses these challenges by contributing to a fundamental understanding of climate change impacts on alpine mass movements, resulting risks, and possible adaptation strategies. More than 50 scientists at WSL and SLF collaborate on 22 research and 5 outreach projects. In the first phase of the program, three research work packages investigated: (WP1) how climate change affects alpine mass movements; (WP2) how their dynamics and impact change under altered initial conditions, flow dynamics, and interactions with ecosystems; and (WP3) how these changes alter the risk and how society can adapt. In a second phase two additional work packages address: (WP4) how cascading processes can be modeled for risk assessment; and (WP5) how early detection and warning systems can be improved.

CCAMM makes considerable efforts to translate and transfer results to practice, the public and back to academia through several outreach activities (WP6). This includes an illustrated synthesis report, a summary for policy-makers, interactive presentations and workshops in several regions of Switzerland, videos, and national and international conferences. All these activities target the installation of robust mitigation and adaptation measures in mountain regions.



Major achievements since 2019

Downscaling climate change scenarios

Hourly resolved temperature and precipitation data for the Inter-Cantonal Measurement and Information System network, based on grid data of Swiss climate scenarios, is an innovative product of CCAMM. The aim of this temporally and spatially downscaled data product is to adequately represent the complex alpine topography, for example in numerical modeling of mass movements in alpine terrain.

envidat.ch/#/metadata/climate-change-scenarios-at-hourly-resolution

Changes in sediment disposition

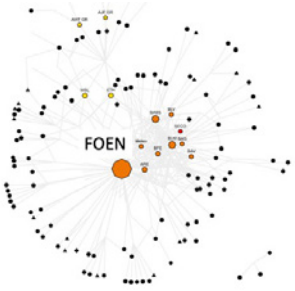
To better anticipate the amount of mobilized material triggered by extreme rainfall or permafrost thaw, CCAMM researchers predicted the change in sediment production and storage, as well as the magnitude and frequency of debris flows, in Illgraben, Valais. Results indicated that the number of future debris flows will likely decrease below 2000 m a.s.l., while it may increase at higher elevations.

wsl.ch/sediment-disposition

The role of deadwood on rockfall dynamics

The protection capacity of forests against rockfall, with and without deadwood, can be quantified with numerical modeling. Full-scale experiments have shown that in the first years after windthrow events, disturbed forests with lying deadwood have an even greater protective effect than standing forests.

Mapping climate adaptation governance



Climate adaptation in the field of natural hazards mainly takes place at the cantonal and municipal levels. Because of a lack of clear legal mandates or dedicated funds, it is driven by individual initiatives following local climate change impacts or extreme events. The main actor at the federal level is FOEN, which fosters cross-sectoral coordination (large circle of points in the depicted actor network).

wsl.ch/gov-vis-cca

Program

envidat.ch

EnviDat

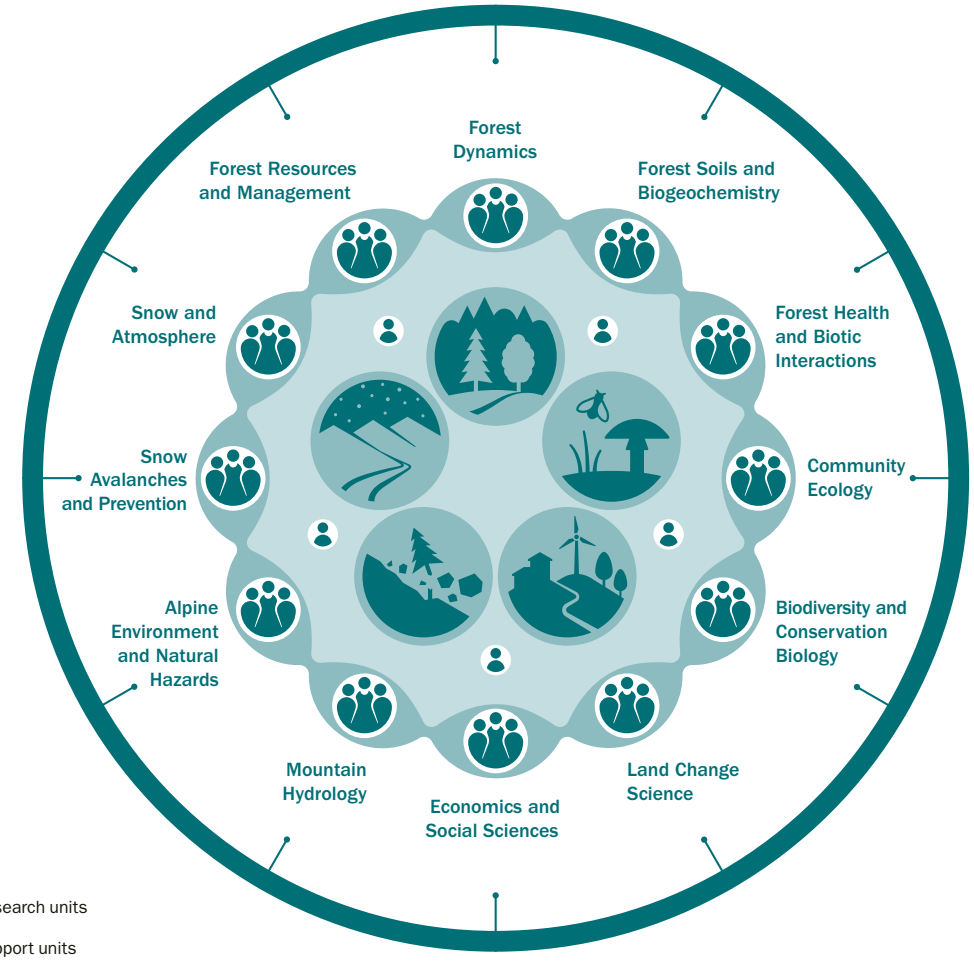
Aims and scope

The EnviDat program was established in 2017 as a long-term strategic initiative to support open science and best practices in research data management for the entire WSL. The program supports scientists with the hosting, publication and dissemination of environmental datasets from forest, landscape, biodiversity, natural hazards, and snow and ice research. EnviDat advises researchers and provides tools and services to WSL scientists in all matters concerning Open Research Data (ORD).

EnviDat is responsible for the development and long-term operation of WSL's environmental data portal, providing unified and managed access to WSL's collection of long-term environmental monitoring and research data. The portal actively implements FAIR (findability, accessibility, interoperability and reusability) principles of formal data publication with associated citation information and digital object identifiers (DOIs). Researchers have the possibility to restrict anonymous access to datasets in EnviDat for reasons such as legal restrictions or data usage reporting.

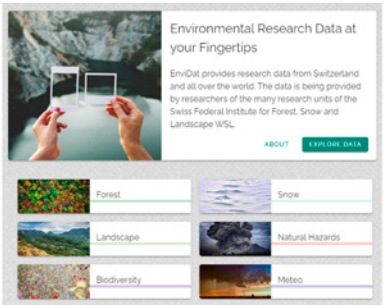
EnviDat is positioned and operated in a highly competitive environment with strong local, national and international initiatives. Therefore, it is closely integrated and connected with other programs at the national, European and global levels. With EnviDat, WSL aims to foster international research cooperation in the field of environmental science and contribute to the ongoing cultural evolution towards open science.

The program paves the way for a user-oriented WSL environmental data service and highlights WSL's commitment to making research datasets accessible to the national and international research communities, stakeholders and the public. Ultimately, the aim of EnviDat is to increase the visibility of WSL's open research data to the global environmental science community.



Major achievements since 2019

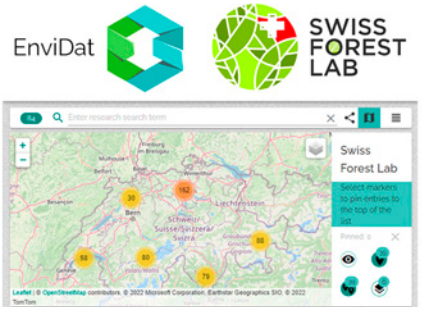
Establishment of the modern and responsive EnviDat portal



The EnviDat portal, employing state-of-the art technologies for research data management and publication, was established and is now well integrated into the WSL research lifecycle. The portal facilitates user-friendly publication, hosting, and search and retrieval of datasets. Cooperation with Eawag and the DOI Desk of ETH Zurich supported EnviDat's development.

envidat.ch

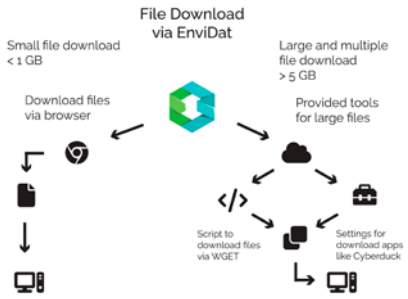
Data portal solutions for long-term WSL programs



EnviDat has developed targeted data portal solutions for long-term WSL programs. Datasets, infrastructures and models from the Long-term Forest Ecosystem Research (LWF) program, the Swiss National Forest Inventory (NFI), and SwissForestLab have been successfully integrated.

envidat.ch/#/browse?mode=swissfl

State-of-the-art repository for large datasets



In collaboration with SWITCH (www.switch.ch), EnviDat has used the latest hybrid-cloud technologies to establish fast and user-friendly downloading of large sets of open WSL research data with complex directory structures and many thousands of individual files. SWITCH is a Swiss foundation that has operated the Swiss university science network since 1987.

envicloud.wsl.ch

Integration with (inter)national data portals

EnviDat is integrated with large institutional portals, such as opendata.swiss (the Open Governmental Data portal of the Swiss confederation), data.europa.eu (the European open data portal), and the international portals for earth data of the European Space Agency (ESA) and the US National Aeronautics and Space Administration (NASA).

envidat.ch/beta/#/integration

Program

wsl.ch/extremes

Extremes

Aims and scope

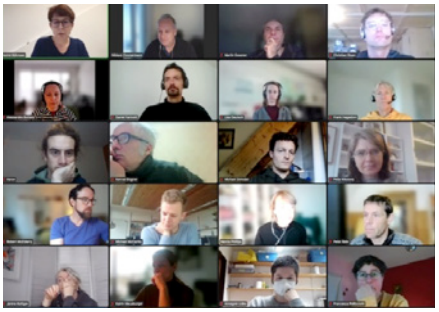
The Extremes program was launched in November 2021 as a strategic initiative of WSL in the planning period 2021–2024. It is a response to the observed trend of an increased frequency of extreme events in Switzerland and globally. The focus is primarily on infrequent and irregular events that are likely to cause massive impacts on society and the environment. The summer drought in 2018, for instance, severely impacted various sectors and ecosystems. Coping with the consequences is challenging for stakeholders because they cannot base their decisions and measures on past experience.

The aim of the program is to anticipate the unknown in order to provide stakeholders with updated knowledge, predictions, projections and early warning systems. The program has followed a bottom-up development process, with stakeholder needs being considered early in the process. Five inter- and transdisciplinary research teams have started work in the program, many of them focusing on extreme drought and related effects. The identification of extreme, yet realistic, megadrought scenarios is crucial for the accurate modeling of possible consequences, such as permafrost thaw and the potential release of pollutants to alpine streams, bark beetle outbreaks and spruce dieback in protection forests, and the increased risk of wildfire. The program also considers societal and technological trends, such as artificial light at night and related effects on nocturnal insects and human well-being.

The anticipated products of Extremes are determined in close consultation with stakeholders, who have been invited to join project teams and are part of the program's steering committee. From early in the program, strong efforts have been made to promote knowledge integration, e.g., through the development of a joint storyline, the use of common baseline scenarios, and the continued training of program members in interactions with stakeholders.

Major achievements since 2021

Participative and integrative program development



In a series of nine online workshops involving WSL researchers, the program was scoped using both top-down and bottom-up development processes. These processes fostered the engagement of peers, a collaborative spirit across research units and disciplines, and the integration of their ideas into the program design and the development of interdisciplinary project proposals.

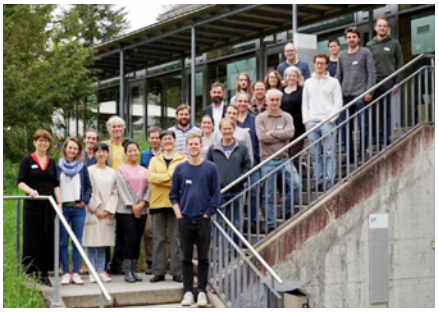
wsl.ch/extremes

Towards real-world solutions

To take stakeholder needs into account and to build on existing resources, the program has emphasized close cooperation with practitioners right from the start. A digital marketplace for stakeholder ideas was established and various training sessions were offered to promote tools for an efficient dialogue between science and practice and to ensure the real-world relevance of solutions coming from research.

wsl.ch/ktt

The program is in full swing



On 4 November 2021, the program officially started with a kick-off meeting including project partners, stakeholders and external guests. To promote the concept of a joint synthesis, regular program meetings have been convened, bringing together program coordinators, project teams, and stakeholders.

wsl.ch/extremes

Program

wsl.ch/bgb

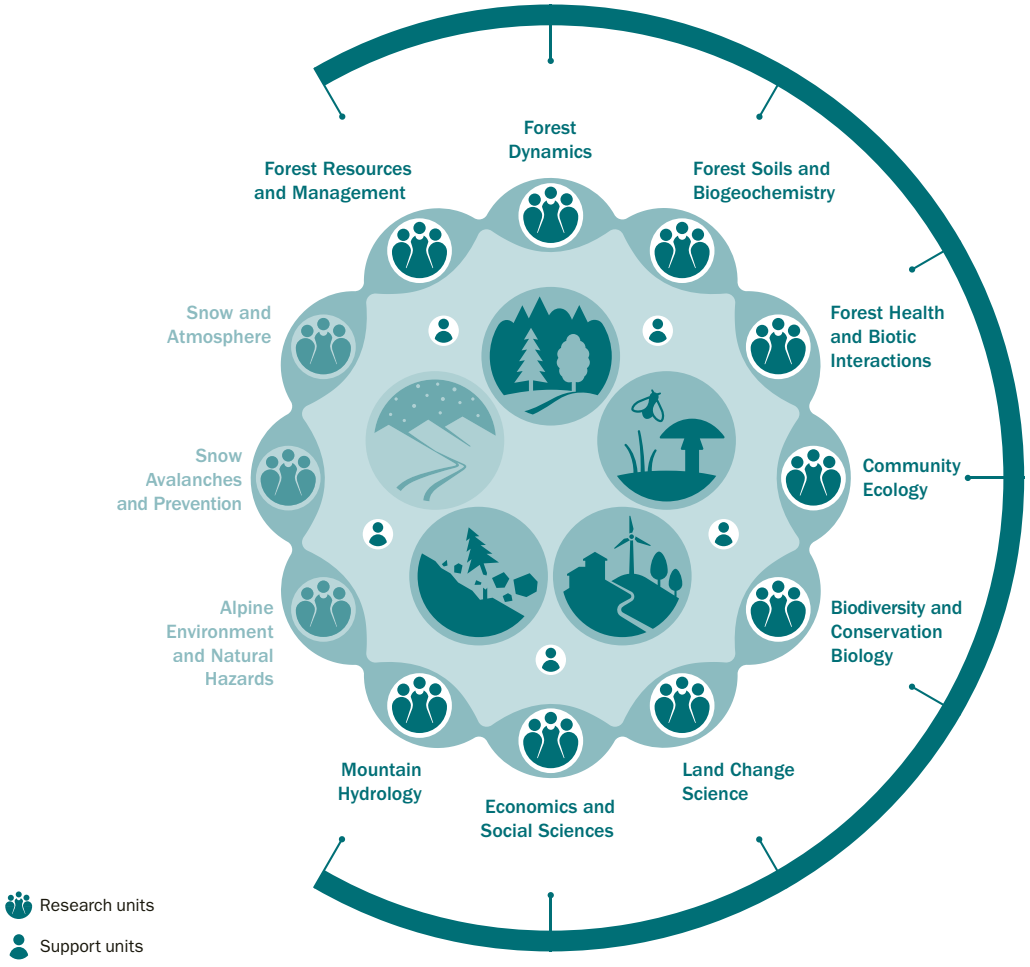
Blue-Green Biodiversity Research Initiative 2021–2024

Aims and scope

The joint Blue-Green Biodiversity Research Initiative with Eawag was launched in response to the urgent need to better understand and mitigate human impacts on aquatic and terrestrial ecosystems. Habitat loss and climate change fundamentally alter biodiversity, with even greater effects projected for the future. To tackle this scientifically and societally urgent topic, the BGB Initiative brings together expertise from more than 50 scientists in the field of biodiversity and associated ecosystem functions and services. The strengthening of interdisciplinary collaborations in the study of biodiversity between WSL and Eawag, as well as across the whole ETH domain, is a major aim of the initiative.

There is growing evidence that impacts may differ substantially between terrestrial and freshwater ecosystems. The initiative was set up in two phases, with the overall aim of improving the understanding of the linkages, similarities and differences between freshwater and terrestrial ecosystems, in terms of their biodiversity, ecosystem functioning, and responses to global change. Thirteen funded research projects focused on analyzing existing data were implemented in 2020. In 2021, eight longer-term projects started: five in research, covering urban biodiversity, beaver habitat ecology, forest micro- and macrofauna food webs, alpine cyanobacteria, and model-based conservation strategies; and three in implementation, with the aims to produce teaching material, enhance the planning of river restorations, and promote biodiversity in peri-urban areas.

Another core component of the BGB Initiative is the training of early-career researchers in application and outreach, enabling them to provide effective guidance for management. This involves creating a value chain leading to implementation, i.e., conservation and restoration. To this end, numerous activities of this initiative, such as workshops, practitioner visits and videos, focus on communication with stakeholders, practitioners and the broader public.



Major achievements since 2020

Scientific article: climate and nutritional flux

Aquatic insects are important in bird diets, especially as they have more fatty acids than terrestrial insects. As an example, a purple martin *(Progne subis)* is depicted feeding a dragonfly to its chick. As the phenology of aquatic insects is advancing with climate change more rapidly than that of birds, mismatches can occur. A scientific article on this topic was published, and the findings were shared via multiple forms of Swiss media.

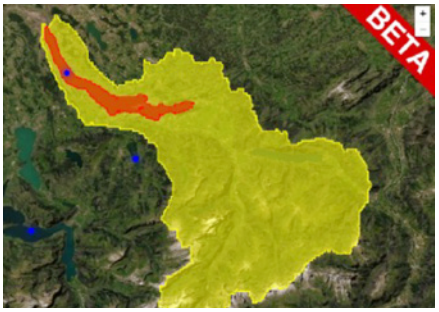
doi.org/10.1016/j.cub.2022.01.057

Outreach articles: blue-green integration

In a series of outreach articles, the BGB Initiative emphasized that the patterns and causes of changes in biodiversity can often only be uncovered and addressed in a practical manner by considering land and water habitats together.

dora.lib4ri.ch/wsl/islandora/object/wsl:29882

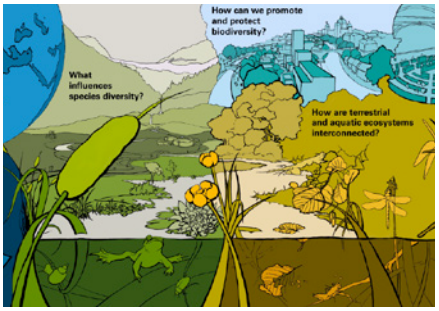
Global phenology map of blue-green ecosystems



In collaboration with the Plymouth Marine Laboratory, the BGB Initiative created a website documenting the phenology of more than 4000 lakes and their watersheds around the globe. The website is the product of an outreach campaign and serves as a starting point for scientific collaborations within and beyond the ETH Domain.

bgbphenology.com

Blue-green biodiversity workshop



Nearly 100 researchers participated in the BGB workshop in Dübendorf in September 2021. A scientist from Finland and a FOEN official gave keynote speeches. The workshop concluded with stimulating breakout sessions.

yumpu.com/user/eawagaquaticresearch

Program

lfi.ch

Swiss National Forest Inventory NFI

Aims and scope

The Swiss National Forest Inventory (NFI) monitors the current state of and the changes to the Swiss forest. Its data series began with periodic surveys in 1985, 1995 and 2006. Since 2009, the NFI has been a continuous activity in which a systematic subset of one-ninth of a total of 6500 sample plots are surveyed each year. More than 300 variables are recorded for each plot. Core data originates from aerial photographs, terrestrial surveys and interviews with the forest service. The fifth inventory is currently underway.

The NFI data catalog has been continuously developed to cover information needs regarding all forest functions, taking into account legal requirements, methodological advances and financial feasibility. The NFI is a legal mandate of WSL; as a joint task of FOEN and WSL, it is funded by both institutions. While WSL is responsible for planning, surveys, analysis, scientific interpretation and publication of the NFI results, FOEN is in charge of political implementation.

Besides providing about 50% of the data for the national reporting on sustainable forest management (e.g., Swiss Forest Report 2015), the NFI program offers a wide range of additional services. These include, among many others, data management, teaching, scientific and outreach publications, maintenance of a data and information portal, development of digital maps, support of cantonal forest inventories, Swiss greenhouse gas reporting, and other international reporting obligations.

The NFI cooperates actively with partners in national and international monitoring projects, such as Swiss Land Use Statistics and the Global Forest Resource Assessment of the FAO. It is a steering group member of ENFIN.

Major achievements since 2019

Book: Swiss National Forest Inventory

This book documents almost all aspects of the Swiss NFI, from data collection to the presentation of results. It describes, for instance, the sampling design, methods, forecasting models, data warehousing, and quality assurance measures. In this way, the book enables the reproducibility of NFI activities and serves as a blueprint for other forest inventories.

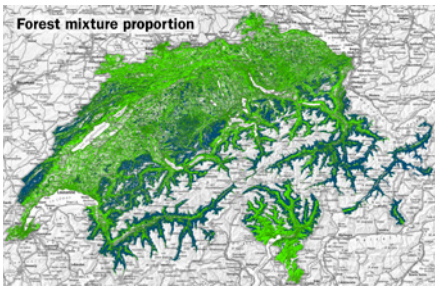
doi.org/10.1007/978-3-030-19293-8

Results of NFI4 (2009–2017)

Knowledge about the state of and changes to the Swiss forest between 2009 and 2017 is essential for stakeholders in science, policy and management. Key information derived from NFI4 is presented in a book and on the NFI web portal.

lfi.ch

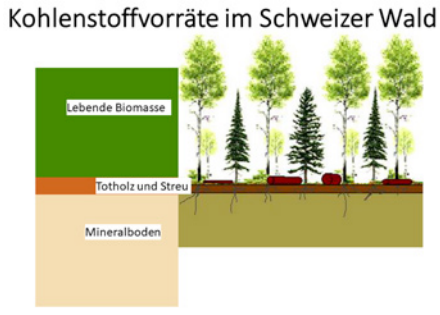
Swiss-wide maps and web applications of the NFI



Swiss-wide maps have gained importance in science, outreach and policy-making. To meet the increasing demand for such products, the NFI now provides freely available Swiss-wide maps that are part of the base-geodata of Switzerland.

lfi.ch/produkte/karten-en.php

Greenhouse gas inventory



The Swiss greenhouse gas inventory comprises annual greenhouse gas emissions from Switzerland and is published by FOEN for the attention of the UNFCCC. For this purpose, the NFI provides annual carbon balances and modeled future developments of the Swiss forest as reference scenarios.

climatereporting.ch

Program

wsl.ch/lwf

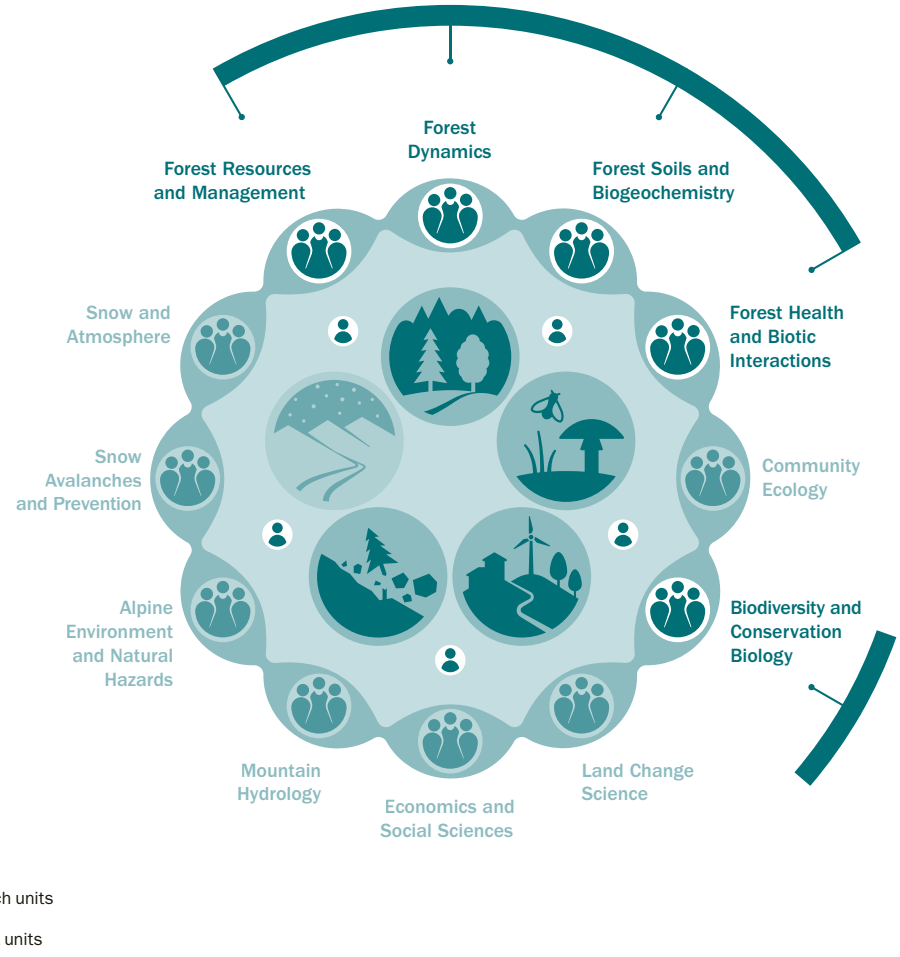
Long-term Forest Ecosystem Research LWF

Aims and scope

The Long-term Forest Ecosystem Research (LWF) program was launched in 1994 to continuously record forest conditions. The aims of the program are to understand how environmental factors, such as climate change and air pollution, impact forest systems. The program additionally fulfills mandates within the framework of Swiss laws (e.g., forest law) and international conventions (ICP Forests).

To this end, LWF conducts annual surveys of forest health at 48 ICP Forests level I and 18 level II sites in Switzerland, in collaboration with FOEN. This includes the assessment of parameters such as crown defoliation, tree mortality and tree growth, as well as the determination of nitrogen deposition and ozone concentrations. Consistency of data and methods over long periods and across the whole European network is of utmost importance. Emphasis is also placed on the development and inclusion of novel monitoring techniques, such as close-to-real-time information on forest status, as well as drone- and satellite-based remote sensing. Another LWF task is monitoring-related research, for example the combination of models with monitoring data to forecast ecosystem functioning.

The LWF program annually reports forest health data to ICP Forests and FOEN. Further, it reports sustainable forest management indicators (e.g., air pollutants, soil conditions, defoliation and forest damage) to the Ministerial Conference on the Protection of Forests in Europe (MCPFE), thus contributing to the harmonization of Europe-wide information on forests for decision-makers. Additional research and monitoring activities with international and national collaborators (e.g., ICOS and eLTER) add value to the program.



Major achievements since 2019

Consistent forest status reporting since 1994

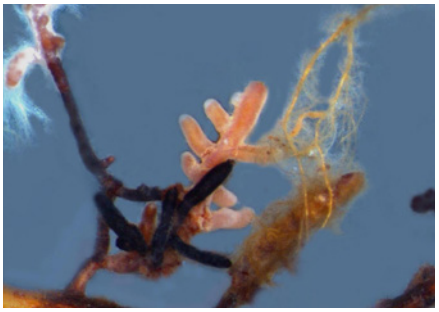
The LWF program contributes to the annual reporting of forest conditions at the national and international levels. Such long-term information, collected with consistent methodologies together with ICP Forests partners all over Europe, makes it possible to evaluate the trajectories of forest ecosystems and their services in a changing climate.

Leading role in publishing ICP Forests results

The results of a study assessing nitrogen deposition effects on forest growth indicate that, together with stand density and age, N deposition is at least as important as climate in modulating forest growth at the continental scale in Europe.

doi.org/10.1016/j.foreco.2019.117762

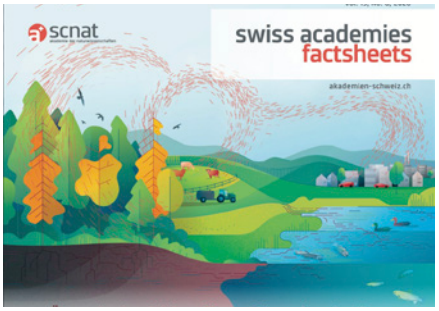
Sharing infrastructure and data for better science



LWF data and infrastructure are provided in collaborations with national and international partners. Results from one investigation suggest that mycorrhizal fungi composition is a strong bio-indicator of underlying drivers of tree growth and that variation in forest mycorrhizal communities causes differences in tree growth.

doi.org/10.1038/s41396-021-01159-7

Information for policy-makers



LWF provides science-based recommendations for decision-makers. In Switzerland, too much nitrogen and phosphorus continue to enter the environment. If the negative effects on biodiversity and ecosystem services are to be reduced, the causes of excessive inputs must be urgently addressed. This factsheet, produced by LWF, provides recommendations for action in this regard.

Center

cerc.slf.ch

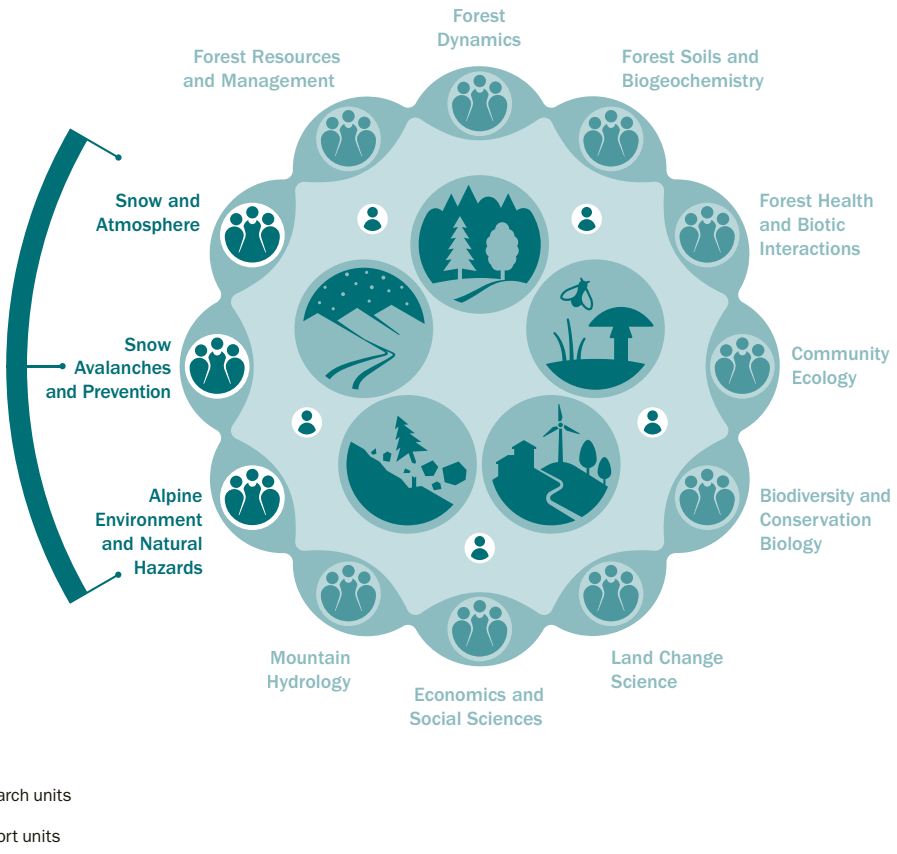
Climate Change, Extremes and Natural Hazards in Alpine Regions Research Centre CERC

Aims and scope

On 1 January 2021, the Climate Change, Extremes and Natural Hazards in Alpine Regions Research Centre (CERC) was established as a new research center based at the WSL Institute for Snow and Avalanche Research SLF in Davos. As one out of three strategic initiatives of WSL, the aim of the center is to develop practical solutions for the growing challenges in mountain regions posed by natural hazards and extreme events under climate change.

CERC is focused on six thematic areas where particular effort is needed in the future and where the potential for expanding existing expertise at SLF is great. These topics are: weather and climate extremes in the Alpine region; permafrost; alpine remote sensing; alpine mass movements; mountain ecosystems and protection forests; and early detection and warning as a measure for risk management, communication and resilience. Striving for inter- and transdisciplinarity, CERC integrates these diverse topics and works across institutions. CERC also serves as a bridge between different research units and programs of WSL, such as CCAMM and Extremes, and promotes their long-term implementation specifically in mountain regions.

As a cross-sectional research, knowledge and implementation hub, CERC links the cutting-edge research of WSL and ETH Zurich with the regional knowledge available in the canton of Grisons and in other mountainous regions. This is enabled through funding from WSL and Canton Grisons and strengthened by two joint professorships with ETH Zurich. The two appointed professors, in Alpine Mass Movements and in Hydrology and Climate Impacts in Mountain Regions, will start work at CERC in Davos in fall 2022. In Canton Grison's Innovation Strategy 2028, CERC is defined as one of two lighthouse projects that position Grisons as a prominent research location in the longer term.



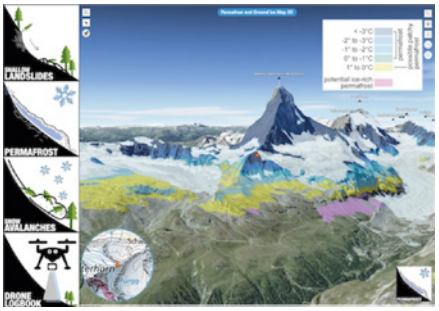
Major achievements since 2021

Establishment of CERC

CERC was established in 2021 as a cross-sectional research and implementation hub of SLF, with strong links to ETH Zurich, Canton Grisons, and other partners. The organization of the center was consolidated both internally and externally and summarized in a guidance and mission statement paper.

cerc.slf.ch

Interactive web maps



CERC researchers have developed new and creative ways to collaborate through interactive 3D maps. These maps link CERC's interdisciplinary research with transdisciplinary approaches to collaboration. One application is SLF's new permafrost and ground ice map (PGIM), which helps researchers to evaluate local and regional permafrost distributions.

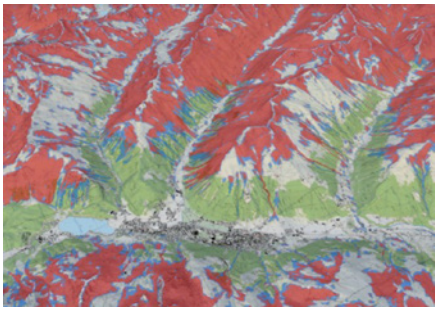
maps.wsl.ch | *slf.ch/pgim*

Disturbance dynamics and ecosystem services

Long-term data after windthrow and bark beetle outbreaks has provided new insights into disturbance development and resilience. In combination with in-situ experiments and process models, this data has additionally made it possible to reconstruct natural hazards and ecosystem services after natural disturbances. CERC has initiated follow-up projects focusing on integrative decision support.

wsl.ch/mountain-habitats-changing | *doi.org/10.1016/j.foreco.2022.120201*

Large-scale hazard and risk mapping



CERC researchers developed large-scale hazard indication maps for the entire canton of Grisons, in cooperation with the cantonal Department of Forests and Natural Hazards (AWN). In an iterative process and working with regional specialists, the product was improved and is currently being developed further towards interactive risk maps under changing environmental conditions.

wsl.ch/mapping-avalanches | *doi.org/10.5194/nhess-22-1825-2022*

Center

WSL Biodiversity Center

wsl.ch/biodiversity-center

Aims and scope

WSL has extensive expertise in the area of biodiversity research. The Biodiversity Center pools this expertise and ensures that the research results are available to all interested parties. Founded in 2020, the Center's main focus is to support biodiversity research and outreach through networking and capacity building at WSL. It has the following main aims: (1) to increase networking within WSL, nationally and internationally; (2) to identify and capitalize on synergies between scientists within WSL and with other institutions; and (3) to increase the visibility of WSL biodiversity research to scientists and practitioners.

The Center currently sponsors several activities, including: (1) Biodiversity seminars: the goal is to increase interaction among WSL scientists and raise awareness of hot topics in research and application. These events increase knowledge transfer and facilitate contact with renowned keynote speakers. (2) Innovation workshops and working groups: the goal is to facilitate networking, communication and identification of synergies. Recent workshops have included an environmental DNA event series in collaboration with Eawag, a spatial autocorrelation workshop, and workshops in computer vision in ecology and evolution. The benefits are increased awareness of hot topics in biodiversity research, but also topics that are important for practitioners. (3) Summer schools: the goal is to build capacity and increase knowledge transfer and visibility. These schools are organized alone or in collaboration with other institutions. The most recent summer school was on forest biodiversity and was offered in collaboration with SwissForestLab. These schools benefit WSL by increasing its visibility, recruiting young talent, and branding WSL across a range of topics. (4) Biodiversity Research Day: the goal of this joint symposium is to enhance awareness and interaction of biodiversity research across WSL.

WSL Landscape Centre

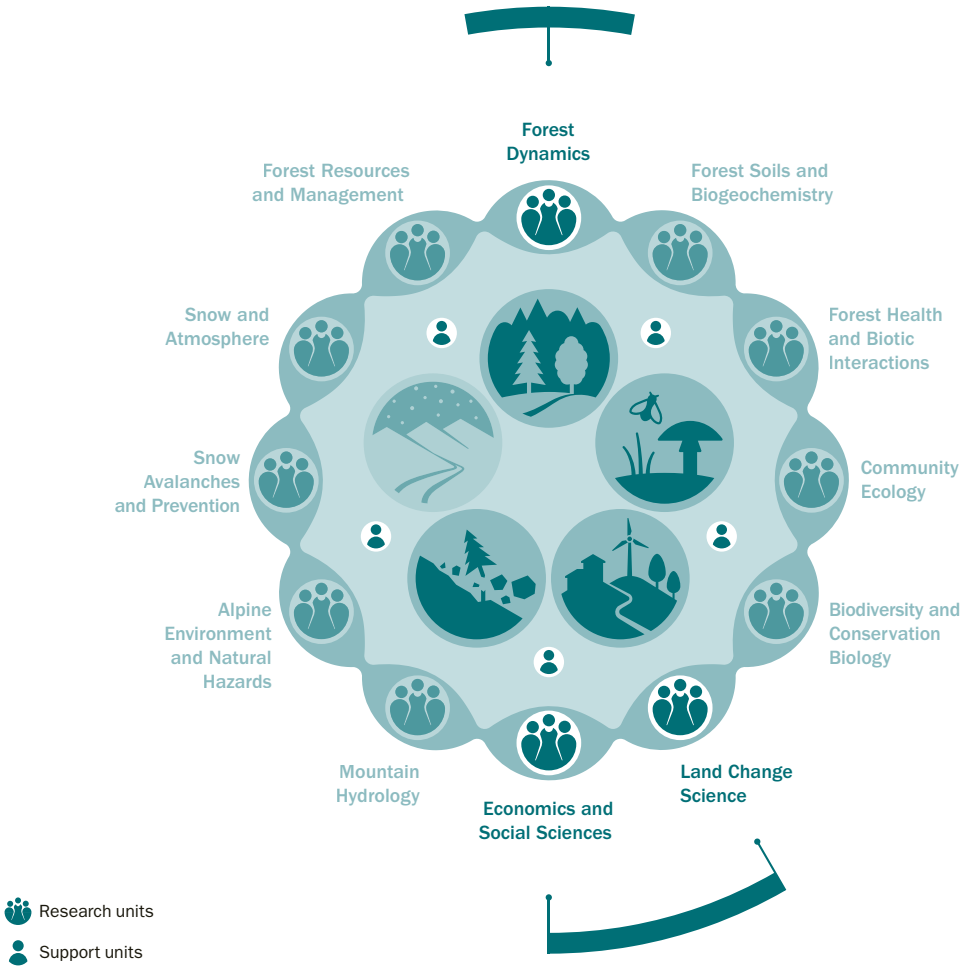
Center

wsl.ch/landscape-centre

Aims and scope

WSL has extensive expertise in the area of landscape research, covering a wide range of topics, from landscape history, to landscape ecology, to social and economic issues. The Landscape Centre, founded in 2012, pools this expertise to increase the visibility of WSL landscape research. Its main aims are: (1) to connect landscape researchers within WSL and with other institutions, (2) to raise awareness of landscape research both nationally and internationally, and (3) to make results available to partners from authorities at the national, cantonal and municipal levels, as well as to NGOs and practitioners.

The Landscape Centre is active in the following areas: (1) Research network: the Centre plans and coordinates research activities in collaboration with WSL landscape researchers from different research units. It supports the WSL Directorate in strategic issues relevant to landscape research. It emphasizes supporting early-career scientists, for example, by organizing Junior Scientist Conferences, a platform where young scientists from Switzerland and abroad can present results and exchange ideas. The Landscape Centre also engages in projects with a strong focus on implementation, such as the visualization of landscape scenarios under climate change or the assessment of tranquil landscapes in Switzerland. (2) Teaching: members of the Landscape Centre actively contribute to teaching in the ETH Domain, as well as at universities and universities of applied sciences. The Landscape Centre offers international summer schools on, for instance, land-system science, in collaboration with partner universities from the Netherlands and ETH Zurich. (3) Transfer of knowledge: the Landscape Centre ensures that results are put into practice, to inform society and authorities. For example, it organizes conferences and workshops with practitioners, publishes regularly in practice-oriented journals, and issues reports.



Appendix: List of Abbreviations

AI	artificial intelligence
ARE	Federal Office for Spatial Development
AUS	unmanned aerial system
AWN	Department of Forests and Natural Hazards, Canton Grisons
BGB	Blue-Green Biodiversity Research Initiative
BSTB	Federal Civil Protection Crisis Management Board
CAS	Certificate of Advanced Studies
CCAMM	Climate Change Impacts on Alpine Mass Movements
CCES	Competence Center Environment and Sustainability
CERC	Climate Change, Extremes and Natural Hazards in Alpine Regions Research Centre
CHELSA	Climatologies at High Resolution for the Earth's Land Surface Areas
COST	European Cooperation in Science and Technology
CRYOS	Laboratory of Cryospheric Sciences, EPFL
CSC	China Scholarship Council
CWTS	Centre for Science and Technology Studies
DNL	Datacenter Nature and Landscape
DOI	digital object identifier
DORA	Digital Object Repository
EAFV	Federal Institute for Forest Research
Eawag	Swiss Federal Institute of Aquatic Science and Technology
EAWS	European Avalanche Warning Services
eDNA	environmental DNA
EGU	European Geosciences Union
EISLF	Swiss Federal Institute for Snow and Avalanche Research, Davos-Weissfluhjoch
eLTER	Integrated European Long-Term Ecosystem, critical zone and socio-ecological Research program
Empa	Swiss Federal Laboratories for Materials Science and Technology
ENFIN	European National Forest Inventory Network
EnviDat	Environmental Data Portal, WSL
EPFL	Swiss Federal Institue of Technology Lausanne (École polytechnique fédérale de Lausanne)
ERC	European Research Council
ESA	European Space Agency
ESKAS	Swiss Government Excellence Scholarships
ETH Zurich	Swiss Federal Institue of Technology Zurich (Eidgenössische Technische Hochschule Zürich)
EVOLTREE	EVOLution of TREEs as drivers of terrestrial biodiversity
FAIR	findability, accessibility, interoperability and reusability
FAO	Food and Agriculture Organization of the United Nations
FiBL	Research Institute of Organic Agriculture
FOAG	Federal Office for Agriculture
FOEN	Federal Office for the Environment
FoLAP	Forum Landscape, Alps, Parks (SCNAT)
FOPH	Federal Office of Public Health
GCOS	Global Climate Observing System, Switzerland
GDC	Genetic Diversity Centre, ETH Zurich
GLP	Global Land Project
GTN-P	Global Terrestrial Network for Permafrost
GWG	Gebirgswaldpflegegruppe
HOMED	Holistic Management of Emerging Forest Pests and Disease
HPC	high-performance computing
IACS	International Association of Cryospheric Sciences
IALE	International Association for Landscape Ecology
ICOS	Integrated Carbon Observation System
ICP Forests	International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests
IGS	International Glaciological Society
INRAE	National Research Institute for Agriculture, Food and Environment, France
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPSAS	International Public Sector Accounting Standards
IUCN	International Union for Conservation of Nature
IUFRO	International Union of Forest Research Organizations
KTT	Knowledge and Technology Transfer
LABES	Swiss Landscape Monitoring program
LAINAT	Steering Committee for Intervention in Natural Hazards
LID	Laboratory of Ion Beam Physics, ETH Zurich
LWF	Long-term Forest Ecosystem Research program
MbO	Management by Objectives
MCPFE	Ministerial Conference on the Protection of Forests in Europe
MCS	mean citation score
MeteoSwiss	Federal Office of Meteorology and Climatology
micro-CT	micro-computed tomography
MNCS	mean normalized citation score

MOOC	Massive Open Online Course
MOSAiC	Multidisciplinary drifting Observatory for the Study of Arctic Climate
MOU	memorandum of understanding
NASA	National Aeronautics and Space Administration, USA
NCCS	National Centre for Climate Services
NFI	National Forest Inventory
NFZforest.net	Nancy-Freiburg-Zurich Forest Research Network
NGO	non-governmental organization
OA	open access
ORD	Open Research Data
PD	Privatdozent
PERMOS	Swiss Permafrost Monitoring Network
PGIM	permafrost and ground ice map
PLANAT	National Platform for Natural Hazards
PP top 10%	proportion of publications in the top 10% most cited publications
PSI	Paul Scherrer Institute
RAMMS	Rapid Mass Movement Simulation software suite
SAR	self-assessment report
SCNAT	Swiss Academy of Sciences
SDC	Swiss Agency for Development and Cooperation
SDSC	Swiss Data Science Center
SERI	Swiss State Secretariat for Education, Research and Innovation
SFOE	Swiss Federal Office of Energy
SLF	WSL Institute for Snow and Avalanche Research SLF
SMOS	Soil Moisture and Ocean Salinity
SNSF	Swiss National Science Foundation
SPI	Swiss Polar Institute
SPPS	Swiss Federal Plant Protection Service
SwissAIM	Advanced Inventorying and Monitoring System for Swiss Forests
SwissTopo	Federal Office of Topography
TCS	total number of citations
ToR	term of reference
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
USYS	Department of Environmental Systems Science, ETH Zurich
VDC	Virtual Data Center
WaMos	Sociocultural Forest Monitoring
WBS	Monitoring the Effectiveness of Habitat Conservation in Switzerland
WHFF-CH	Wald- und Holzforschungsförderung Schweiz
WHO	World Health Organization
WMO	World Meteorological Organization
WoS CC	Web of Science Core Collection
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research