



Strategic Planning

WSL Development Plan 2021–2024

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Table of Contents

Table of Contents	2
Preamble	4
Executive Summary	5
1. Introduction	6
1.1. Mandate and Foundation for Development Planning	6
1.2. WSL Process for Development Planning 2021–2024	6
2. Framework and Positioning of the Institution	8
2.1. Organization	8
2.2. Background and Mandate	9
2.3. National Tasks	10
2.4. Values	11
2.5. WSL Research Focus Areas: Current Status	12
2.5.1 Forest	12
2.5.2 Landscape	14
2.5.3 Biodiversity	15
2.5.4 Natural Hazards	16
2.5.5 Snow and Ice	17
2.6. Teaching	18
3. Strategic Orientation	20
3.1. New WSL Strategic Initiatives	20
3.1.1 Blue-Green Biodiversity (BGB)	21
3.1.2 Extremes	21
3.1.3 Climate Change and Extremes Research Center (CERC) in Davos	22
3.2. WSL Research Focus Areas: Strategic Orientation	23
3.2.1 Forest	24
3.2.2 Landscape	25
3.2.3 Biodiversity	26
3.2.4 Natural Hazards	26
3.2.5 Snow and Ice	28
3.3. WSL Contribution to Strategic Focus Areas in the Strategic Plan 2021–2024 of the ETH Board	29
3.3.1 Data Science	29
3.3.2 Energy & Environment	30

4. Goals and Actions According to the Strategic Development Goals 2021–2024 of the Federal Council for the ETH Domain.....	31
4.1. Teaching.....	31
4.2. Research.....	32
4.3. Research Infrastructures and Large-scale Research Projects	32
4.4. Knowledge and Technology Transfer.....	33
4.5. National Cooperation and Coordination.....	34
4.6. International Positioning and Cooperation	35
4.7. Role in Society and National Tasks	36
4.8. Sources and Use of Finances.....	37
4.9. Real Estate Management and Sustainability	38
4.10. Working Conditions, Equal Opportunity and Young Academics.....	38
5. Implementation Plans	40
5.1. Financial Strategy.....	40
5.1.1 First-party Funding / Base Budget.....	40
5.1.2 Third-party Funding.....	40
5.2. Human Resources Strategy (HR).....	40
5.2.1 Personnel Policy	40
5.2.2 Personnel and Organizational Development	41
5.2.3 Equal Opportunity	41
5.3. Real Estate Strategy	42
5.3.1 Existing Buildings.....	42
5.3.2 Planned Buildings	42
5.4. Information and Communication Technology Strategy (IT)	42
Annex I. List of Acronyms, Names and Abbreviations	44
Annex II. WSL Legal Mandate	48

Preamble

The Swiss Federal Institute for Forest, Snow and Landscape Research WSL¹ is the Swiss Confederation's research institute for terrestrial environmental systems. It is part of the ETH Domain. The ETH Domain comprises six autonomous institutions. There are two different types of institutions: ETHs and research institutes. Two ETHs, the Swiss Federal Institute of Technology in Zurich (ETH Zurich) and Swiss Federal Institute of Technology in Lausanne (EPFL), and four research institutes, the Paul Scherrer Institute (PSI), Swiss Federal Institute for Materials Testing and Research (Empa), Swiss Federal Institute of Aquatic Science and Technology (Eawag) and WSL, make up the ETH Domain.

Together, the ETHs and the research institutes share the responsibility to fulfil the mandate of the ETH Domain in education, research and services. The ETHs and the research institutes are the operational units of the ETH Domain. As autonomous institutions, the ETHs and the research institutes develop strategies for each individual institution, but they also participate in and support the development of the shared strategy of the ETH Domain.

The ETHs bear the fundamental responsibility for tertiary education and are the academic degree-granting institutions within the ETH Domain. The research institutes cannot grant academic degrees, and therefore their educational mandate is fulfilled in partnership with the ETHs or other degree-granting institutions.

The research institutes are legally constrained in the thematic scope of their activities. These thematic constraints reflect political decisions regarding the importance to Switzerland of certain thematic areas. The scope of the activities of the ETHs in science and engineering, on the other hand, is not subject to any thematic constraints. The ETHs must maintain the capacity to meet the needs of education and research in a broad range of fields.

Within the ETH Domain, WSL covers the area of terrestrial environmental research, with the goal of providing solutions that improve the quality of life in a healthy environment. WSL is legally mandated to cover the field of sustainable development, in particular in mountainous regions and urban agglomerations, and to address the thematic areas landscape and biodiversity; forest ecology and forest management; natural hazards and integral risk management; and snow, ice, avalanches and permafrost. In addition, WSL is mandated by federal legislation to provide a range of national services, including running the Swiss National Forest Inventory, the Long-term Forest Ecosystem Research Programme, the Avalanche Warning Service for Switzerland and the Swiss Forest Health Service, providing technical support for forest plant protection, and monitoring the Swiss Natural Forest Reserves.

¹ See Annex I for a list of acronyms, names and abbreviations used in this document.

Executive Summary

The Swiss Federal Institute for Forest, Snow and Landscape Research WSL is the ETH Domain's research institute for terrestrial environmental systems. This development plan presents the strategic plan of WSL for the period 2021–2024. It lays out WSL's vision in basic and applied research, implementation, outreach and teaching. WSL recognizes the need for continued access to up-to-date, high-quality scientific facilities, excellent scientific and technical expertise, and experience in combining research and application for practitioners. The plan also describes WSL's contributions to the Goals and Actions according to the Strategic Development Goals 2021–2024 of the Federal Council for the ETH Domain and, as such, forms a basis for the performance agreement between WSL and the ETH Board. These objectives for a planning period supplement and substantiate the tasks assigned to WSL, which are specified in the federal regulations and in the regulations of the ETH Board.

For the planning period 2021–2024, the WSL Directorate has defined three new strategic research initiatives: (i) Blue-Green Biodiversity (BGB), intended to strengthen aquatic (blue) and terrestrial (green) biodiversity research in the ETH Domain and increase the visibility of WSL and Eawag in this focus area; (ii) Extremes, a targeted research programme on environmental extremes; and (iii) establishment of the Climate Change and Extremes Research Center (CERC) in Davos, focussing on climate change impacts on natural hazards in mountain regions, in close collaboration with ETH Zurich and the canton of Grisons. The three strategic initiatives represent important development areas for WSL over the coming years. They involve all research and support units at WSL. At the same time, WSL will continue its activities in the five focus areas forest, landscape, biodiversity, natural hazards, and snow and ice, while adapting further engagements depending on the overall funding situation and the relevance and potential of a particular topic for WSL and for Swiss society and politics. As a federal research institute, WSL aims to provide excellent research at the international level that results in evident benefits for society and the public in Switzerland. In the planning period 2021–2024, WSL will continue to actively position itself in the dynamic and competitive international setting and maintain its important function as a bridge between basic research and applied science in Switzerland.

1. Introduction

The Swiss Federal Institute for Forest, Snow and Landscape Research WSL is the Swiss Confederation's research institute for terrestrial environmental systems. WSL is part of the ETH Domain and employs approximately 550 permanent staff and 90 apprentices, interns and employees with short-term contracts, for a total of close to 640 employees. WSL additionally hosts roughly 230 Bachelor's, Master's and PhD students, and scientific guests who are not on its payroll. Along with the main WSL office in Birmensdorf, near Zurich, and the WSL Institute for Snow and Avalanche Research SLF in Davos, smaller stations in Lausanne, Cadenazzo and Sion help the WSL generate local synergies and reach out to practitioners and cantonal and local authorities.

1.1. Mandate and Foundation for Development Planning

The Swiss Federal Council assigns the ETH Domain strategic goals that are renewed every four years. The ETH Board, which is responsible for the strategic management of the ETH Domain, formulates the ETH Domain's strategy for a performance period, in dialogue with the institutions of the ETH Domain, and supervises its implementation². The strategic plan is the central tool for defining the key areas in teaching, research and knowledge transfer, and for establishing science policy objectives and determining prioritized large-scale projects for the entire ETH Domain. The document also provides information about the resources required to achieve the strategic goals and serves as a guideline for the activities and development plans of the individual institutes of the ETH Domain.

In keeping with their autonomous status, the ETH Domain's institutions compile individual development plans. These are subject to the approval of the ETH Board, which ensures coordination and harmonization with the strategic goals assigned by the Confederation and the strategic planning of the entire ETH Domain.

Based on the approval of the development plans, the ETH Board forms agreements with the institutions about objectives. In these agreements, the requirements resulting from strategic goals assigned by the Confederation and the ETH Board's strategic plan for the entire ETH Domain are broken down into objectives for the individual institutions. These objectives for a planning period supplement and substantiate the tasks assigned to WSL, which are specified in the federal regulations and in the regulations of the ETH Board (described in Sections 2.2 and 2.3).

1.2. WSL Process for Development Planning 2021–2024

Following the successful process implemented for the previous WSL development plan (for 2017–2020), the WSL Directorate initiated a WSL-wide strategy process in early 2019, involving all research units and research programmes, to strengthen WSL's thematic foci for the planning period 2021–2024. The process also covered personnel and infrastructure planning. Based on this process, the WSL Directorate defined three new WSL strategic initiatives for the planning period 2021–2024 in the areas of

² See Annex II for exact German formulations and references to the legal source documents. As English is not an official language of the Swiss Confederation, the translations in this document are provided for information purposes only and have no legal force.

biodiversity, extreme events, and the establishment of a new research centre in Davos with a focus on climate change and extremes. These three new strategic initiatives, along with WSL's continued activities in the five focus areas forest, landscape, biodiversity, natural hazards, and snow and ice, form the scientific core of the development plan presented here.

2. Framework and Positioning of the Institution

As a federal research institute of the ETH Domain, WSL aims for excellence in research at the international level that results in evident benefits for Swiss society. WSL's mission is to: (i) explore the dynamics of the terrestrial environment, and the use and protection of natural and cultural habitats; (ii) monitor forests, landscapes, biodiversity, natural hazards, and snow and ice; and (iii) develop, in cooperation with its partners in science and society, sustainable solutions for societally relevant issues.

These tasks require both long-term environmental monitoring and the ability to respond quickly and flexibly to developments in science, technology and society, as well as in environmental and climatic conditions. One of WSL's demonstrated strengths is the ability to maintain the balance between continuity and flexibility, as well as between excellent research and practical application and implementation. In fact, WSL has a long tradition of linking science and application in terrestrial environmental systems. Building on its excellence in basic research, WSL advises the Swiss administration and decision-makers at the national, cantonal and community levels and in the private sector, and it provides the basis for political decisions regarding the sustainable use of natural resources and the environment, ultimately contributing to the high quality of life in Switzerland. However, WSL actively positions itself in the dynamic and competitive setting of the Swiss higher education landscape in order to maintain its leading function as a bridge between research, application and society in terrestrial environmental science.

2.1. Organization

WSL research covers five scientific focus areas: forest, landscape, biodiversity, natural hazards, and snow and ice. The scientific activities are organized into eleven research units and six research programmes. The eleven research units cover the topics forest resources and management, forest dynamics, forest soils and biogeochemistry, forest health and biotic interactions, community ecology, biodiversity and conservation biology, land change science, mountain hydrology and mass movements, snow avalanches and prevention, snow and permafrost, and economics and social sciences. The currently active WSL programmes include the monitoring programmes Swiss National Forest Inventory (LFI) and Long-term Forest Ecosystem Research Programme (LWF), as well as the programmes Energy Change Impact (which will come to an end in 2020), SwissForestLab, Environmental Data Portal (EnviDat) and Climate Change Impacts on Alpine Mass Movements (CCAMM). In addition, WSL supports two internal centres, the Landscape Centre and a new Biodiversity Center (see Section 2.5.3), which pool the competencies of WSL in these areas and provide an interface for partners from practice.

Planning and logistics at WSL are organized into six support units: human resources, finances and support, IT, communications, management of facilities in Birmensdorf, and management of facilities in Davos. In addition, WSL shares the library Lib4RI with Eawag, Empa and PSI.

WSL employs an international staff of around 640 people from approximately 36 countries, including 12 apprentices and about 80 interns and non-permanent employees with short-term contracts. In addition, WSL hosts roughly 230 Bachelor's, Master's and PhD students, and scientific guests who are not on its payroll. The proportion of women at the end of 2019 was approximately 38%. Foreign staff accounted for nearly 33%. German was the mother tongue of most employees (80%). On 1 July 2020,

361 of WSL's employees, including roughly 60 PhD students, worked as scientific staff. Of the remaining employees, 214 were technical staff and 64 were administrative staff (including communications). About three-quarters of all WSL employees work in Birmensdorf (76%; 486), about one-fifth work at SLF in Davos (21%; 135), and the remainder work in Cadenazzo (2%; 15), Lausanne (<1%; 3) or Sion (<1%; 1).

2.2. Background and Mandate

The purpose of the institutions within the ETH Domain is, as written in Article 2 of the Federal Act on the Federal Institutes of Technology from 4 October 1991²:

1. The role of the two federal institutes of technology (ETHs) and their affiliated research institutes shall be:
 - a. to educate students and specialists in scientific and technical fields and ensure continuing education and training;
 - b. to expand scientific knowledge through research;
 - c. to foster junior scientific staff;
 - d. to provide scientific and technical services;
 - e. to ensure a dialogue with the public;
 - f. to exploit their research findings.
2. They shall take account the needs of Switzerland.
3. They shall discharge their remit at an internationally recognized level and encourage international cooperation.
4. The guiding principles for teaching and research are respect for human dignity and responsibility in the use of natural resources and the environment, together with an evaluation of the consequences of technological applications.

The autonomy and the duties of the ETH Domain research institutes are, as written in Article 21 of the Federal Act on the Federal Institutes of Technology from 4 October 1991²:

1. Research institutes are autonomous bodies of the Confederation established under public law and with their own legal persona.
2. They shall conduct research within their specified field and render scientific and technical services.
3. In as much as they are able, research institutes shall be available to universities for the purpose of teaching and research.

According to Article 3 of the Regulations of the ETH Board concerning the research institutions of the ETH Domain from 13 November 2003, WSL has the following mandate²:

In the field of sustainable spatial development, WSL is especially active in the development of mountainous regions and urban agglomerations, and focuses on the following areas:

- landscape research;
- forest ecology and forest management;
- natural hazards and integral risk management;
- snow, ice, avalanches and permafrost.

This defines the basic mandate of WSL and sets its thematic focus areas. Biodiversity and water resources, while not explicitly listed, are implicitly included as part of the above-mentioned areas. These ETH Domain regulations and WSL's legal mandate, including the national tasks described in Section 2.3, form the basis for the development plan for the 2021–2024 period.

2.3. National Tasks

In addition to the basic mandate described in Section 2.2, WSL is tasked by federal legislation to provide a range of national services related to the terrestrial environment. Fulfilling these important national tasks requires access to up-to-date, high-quality scientific facilities, excellent levels of scientific and technical expertise, and vast experience in combining research and application for the needs of practitioners. As a federal research institute within the ETH Domain, WSL is well placed to deliver such national services, based on its expertise in science and application. It thus provides, to the greatest extent possible, the following services²:

- 1) *Running the Swiss National Forest Inventory, the monitoring of Swiss Natural Forest Reserves and the Long-term Forest Ecosystem Research Programme:*

In collaboration with the Federal Office for the Environment (FOEN), WSL collects and analyses fundamental data on the status of and changes in Swiss forests with the Swiss National Forest Inventory (LFI) and monitors the long-term development of Swiss Natural Forest Reserves. In addition, WSL investigates how Swiss forests respond to changing environmental conditions through the Long-term Forest Ecosystem Research Programme (LWF) (Art. 37a Paras. 2 and 3 of the Forest Ordinance from 30.11.1992, status as of 01.01.2020).

- 2) *Providing the Avalanche Warning Service for Switzerland and informing the public about avalanche danger:*

The WSL Institute for Snow and Avalanche Research SLF provides the Avalanche Warning Service for Switzerland and informs the public about avalanche danger (Art. 9 Para. 1 Alarm and Security Radio Ordinance from 18.08.2010, status as of 01.01.2019; Art. 3 Para. 2, "Regulations of the ETH Board concerning the research institutions of the ETH Domain" from 13.11.2003, status as of 01.01.2004).

- 3) *Running the Swiss Forest Health Service:*

WSL organizes, together with the cantonal forestry services, the collection of data of relevance for forest protection, provides information about the occurrence of organisms and other factors that may damage forests, and advises the cantonal forestry services in matters of forest protection (Art. 30 Para. 2 of the Forest Ordinance from 30.11.1992, status as of 01.01.2020; Art. 3 Para. 2, "Regulations of the ETH Board concerning the research institutions of the ETH Domain" from 13.11.2003, status as of 01.01.2004).

- 4) *Providing scientific and technical support for forest plant health:*

With regard to the protection of plants against particularly dangerous and harmful organisms, WSL is responsible for scientific and technical aspects of plant health in the forest sector (Art. 103 of the Plant Health Ordinance from 31.10.2018, status as of 01.01.2020; Art. 3 Para. 2,

“Regulations of the ETH Board concerning the research institutions of the ETH Domain” from 13.11.2003, status as of 01.01.2004). Together with the Federal Office for Agriculture (FOAG) and its federal agricultural research institutes, WSL ensures that authorized plant protection products, when applied according to regulations, do not have any adverse effects on humans, animals or the environment (Art. 72. Para. 2, Ordinance on Plant Protection Products from 12.5.2010, status as of 01.01.2020).

Related to these legally mandated national tasks, WSL is involved in several important national initiatives and committees. These include, for example, membership in the Federal Civil Protection Crisis Management Board (BSTB); participation in the steering committee for Intervention in Natural Hazards (LAINAT); involvement in the Swiss Federal Plant Protection Service; and membership in the Swiss National Centre for Climate Services (NCCS), which coordinates the development and propagation of climate services.

Apart from the legally mandated national tasks, WSL provides several additional services in close collaboration with the responsible federal authorities. These include services where synergies with WSL’s research activities or mandates exist. Examples include managing the Swiss forest fire database Swiss-fire, which is mandated by FOEN and is conducted in collaboration with cantonal forest services; monitoring the effectiveness of habitat conservation in Switzerland in the nationally important habitats; primary contributions to the national cryosphere monitoring in the framework of Global Climate Observing System (GCOS) Switzerland for all three elements snow, glaciers and permafrost; maintaining an operational snow-hydrological service, which includes continuous analysis of the spatial and temporal distribution of snow water resources in Switzerland and thereby facilitates improved hydrological forecasting and timely regulation of water resources; assessing the relationship of the Swiss population with the forest through the Sociocultural Forest Monitoring WAMOS; managing the Datacenter Nature and Landscape DNL; managing two national centres for species data and information, SwissLichens and SwissFungi, which compile and process information on the distribution and ecology of Swiss lichens and fungi with the goal of documenting spatial and temporal changes; and operating the Plant Protection Laboratory, which includes a quarantine safety greenhouse.

2.4. Values

WSL is committed to scientific excellence at the international level and to improving the quality of life in a healthy environment. It strives for outstanding research that results in evident benefits for Swiss society. An important additional task of WSL as a federal research institute is to act as a bridge between science and the application of research (knowledge transfer), at both the national and international level, and to do so in an objective and impartial manner. WSL strictly adheres to the principles of scientific integrity and ethical guidelines, thereby creating an inspiring scientific environment and enabling cutting-edge research. In this context, WSL has put in place a data policy to acknowledge its responsibility to make publicly funded research data accessible and to ensure long-term access to environmental research data, in line with the FAIR principles (Findable, Accessible, Interoperable, Reusable). As part of the EnviDat programme, WSL operates and further develops an overarching data portal to facilitate access to its rich reservoir of environmental monitoring and research data (www.envidat.ch) and provides open science support to its researchers. WSL also values active, open and honest communication about its research and other activities and follows international guidelines on effective

science communication (<https://www.wissenschaft-im-dialog.de/>). In this context, the WSL communication strategy is regularly updated to reflect the most pressing needs and requirements of society.

WSL is a responsible employer, offering its staff an exciting and stimulating working environment characterized by:

- transparent information, structures and processes;
- mutual respect;
- the highest possible flexibility and freedom in research within the framework of legal, contractual, corporate and strategic regulations;
- a practised culture of equal opportunity;
- responsible leadership;
- integrity and fairness.

2.5. WSL Research Focus Areas: Current Status

WSL's excellence in performing basic and applied research, at both the national and international level, and in informing decision-makers and practitioners is well reflected in the steady numbers in top-quality, high-impact output. In 2019, WSL researchers authored a total of about 900 publications. The number of scientific, peer-reviewed ISI papers has increased by an average rate of 6% per year since 2015, reaching an all-time high of 532 in 2019. An additional 112 publications from 2019 were peer-reviewed but published in non-ISI journals. Overall, 241 papers published that year appeared in application and outreach journals. Along with this steady high output, the number of WSL publications cited nationally and internationally continues to increase substantially: over the nine-year period 2011–2019, citations of ISI publications with WSL authorship nearly quadrupled, from 8,552 to 31,621. Furthermore, WSL has a strong media presence. In the years 2015–2019, from 1,450 to over 2,300 (record-high in 2019 of 2,319) printed news articles and from 180 to over 430 (record-high in 2019 of 436) radio and television broadcasts were based on information provided by scientists and researchers from WSL.

WSL research activities in its five focus areas of forest, landscape, biodiversity, natural hazards, and snow and ice build the foundation for the 2021–2024 development plan. In the following sections, we provide a brief overview of the current state of WSL activities in these focus areas before outlining the strategy for the upcoming planning period, including three new, targeted strategic initiatives.

2.5.1 Forest

Forests cover about one-third of the surface area of Switzerland, shaping the landscape and affecting the quality of life. Forests provide protection against avalanches and rockfall, reduce soil erosion, regulate water discharge, play a key role in water quality, store carbon in soils and wood, and provide wood as a resource for renewable energy and construction and as a raw material for other uses. Forest ecosystems also provide recreational areas for people and natural habitats for plants, animals and soil organisms, and they are thus important for biodiversity conservation in Switzerland.

Forest ecosystems and their indispensable services to humans are becoming increasingly impacted by the extensive and fast global changes in society and the environment occurring in Switzerland and worldwide. Climate change, loss of biodiversity, invasive biota, the generally low profitability of timber production, and progressive urbanization are among the most pressing environmental and societal

challenges for forests and forestry. All of these factors have the potential to fundamentally alter forest ecosystems, including their biogeochemical cycles and their susceptibility to pests and diseases, and the functions and services provided by them, such as carbon sequestration, wood production, protection against natural hazards, recreation, and habitat for numerous animals and non-tree plant species.

WSL leads research on the sustainable use of forest resources, with the primary goals of securing crucial forest ecosystem functions and services and supporting the resilience and adaptation potential of future forests. WSL research focuses on the key future challenges for forest ecosystems and forest management, including impacts of climate change, invasive biota, plant diseases and pests. As a federal research institute, WSL operates several unique long-term forest monitoring networks, experimental sites and research labs, thereby providing a large database to better evaluate the condition and use of Swiss forests and to improve our understanding of the interrelations and dependencies of different components of forest ecosystems. Examples include the LFI, LWF, Experimental Forest Management, the monitoring of Swiss Natural Forest Reserves, and the Plant Protection Laboratory. The assessment of forest ecosystem responses to environmental change, however, is complex because of the long lifespan of trees, the high above- and below-ground diversity of forest ecosystems, and the numerous interfaces with the environment, society and economy. The characterization of future forest dynamics, the estimation of forest ecosystem services, and the development of sustainable management strategies relevant for current and future societies requires: (i) the combination of long-term monitoring, paleo-forest and paleo-climate information; (ii) data from laboratory and field experiments and surveys; (iii) theoretical understanding; (iv) state-of-the-art modelling approaches; and (v) in-depth knowledge about forest engineering and management practices.

WSL combines all the activities mentioned above in one institute, providing unmatched opportunities and a unique research environment, which contribute to its leading role among the most advanced forest research institutions worldwide. In addition, WSL maintains strong national and international collaborations in the areas of forest ecology and forest management. The SwissForestLab, for example, provides a research network to link scientific expertise and infrastructure in Switzerland, thus bridging disciplines and approaches to accurately characterize and forecast forest dynamics. At the international level, WSL researchers are actively involved in networks such as the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests conducted in the framework of the United Nations Economic Commission for Europe International Cooperative Programme (UNECE ICP Forests), a programme aimed at collecting harmonized data on forest conditions in Europe and beyond and where a WSL scientist presides; the International Union of Forest Research Organization (IUFRO); the Long Term Ecosystem Research Network (LTER); and the Integrated Carbon Observation System (ICOS). As a federal research institute, however, many of WSL's activities include components of applied science and target practitioners in Switzerland at different levels, from the federal to the cantonal and community level, as well as practitioners in the private sector. Hence, WSL promotes knowledge transfer on different scales, for example as a founding member of the forest knowledge platform *waldwissen.net*, with more than 2.5 million users per year, and through the Forest Laboratory Zurich, Switzerland's first freely-accessible forest laboratory concerned with the diverse uses of the forest by society.

2.5.2 Landscape

Landscapes are manifestations of the interplay of natural processes and cultural practices over time. They have outstanding cultural significance for humans and provide habitats for animals, plants and many other organisms. Furthermore, landscapes are the backdrop for natural resource management, as well as a resource themselves, for example for recreation and tourism. Landscapes relate to ecology and society alike and are thus perfectly suited to investigations of sustainable development. Indeed, many environmental and sustainability challenges are rooted in land-use practices that surpass local environmental thresholds and result in unintended negative effects. The importance of landscapes is widely acknowledged by governments and society, as testified by the European Landscape Convention ratified by Switzerland in 2013 and the Landscape Approach advocated by the Global Landscapes Forum (GLF).

Landscape research is a transdisciplinary science focused on the landscape scale that includes the dialogue with stakeholders. Landscape research specifically focuses on the interplay of ecological, economic, and social aspects and the complex, often reciprocal relationships of people, landscape and ecosystems. WSL studies these interactions and develops decision-making tools for the sustainable use and governance of landscapes, in line with the European Landscape Convention.

WSL monitors, analyses and models current and historical landscape change and the underlying processes to understand how landscapes are changing, how anthropogenic and natural drivers cause these changes, and which impacts are to be expected. Prominent examples of WSL monitoring activities include the Swiss Landscape Monitoring Program LABES and the Sociocultural Forest Monitoring WAMOS. WSL researchers continue to pioneer the study of the history of cultural landscapes, the importance of green and blue landscape elements and their configuration for ecological connectivity, landscape planning and regional development instruments, and the assessment of landscape services. Furthermore, WSL investigates how the results can be used to project future developments and to develop sustainable solutions to spatially relevant socio-economic and environmental problems. Specifically, WSL research provides the basis for cost-effective measures of nature and landscape protection and for policy decisions. Recently, WSL landscape research has strengthened its position in the growing field of land-change science, where it has established itself as a recognized international leader in the research on driving forces of landscape change. WSL landscape research clearly recognizes the cultural significance of landscapes and how they provide people with a sense of identity and place. Thus, WSL researchers survey local people's needs, how they perceive the landscape they live in, how they use it for recreation, how they react to different conservation and steering measures, and which factors affect the value associated with landscapes.

WSL landscape research has an excellent international reputation, especially due to its strong interdisciplinary orientation and its comprehensive approach towards all landscapes, including urban, rural and alpine areas. WSL pursues an inter- and transdisciplinary research approach that integrates theories from the natural, social and economic sciences and uses a range of data sources, including historical archives, earth observations and interviews, as well as methods such as modelling and content analysis.

The WSL Landscape Centre, founded in 2012, pools the competencies in this area, while providing a highly esteemed interface for and a link between partners, such as the federal authorities, cantonal and municipal administrations, non-governmental organizations (NGOs) and professional associations.

Furthermore, the centre disseminates knowledge on landscape research nationally and internationally. With its outreach activities, it supports the use of landscape-relevant research results for evidence-based governance and ensures that research questions are co-designed with practitioners. This exchange with stakeholders ensures that WSL research provides an immediate benefit to society.

2.5.3 Biodiversity

Biodiversity can be described on four levels: the diversity of genes, species (including functional trait diversity), ecosystems and their interactions. By ratifying the Biodiversity Convention of Rio (United Nations 1992), Switzerland agreed to monitor, maintain and foster biodiversity. The goals of the Biodiversity Convention were further quantified in the Aichi targets in 2011 (<https://www.cbd.int/sp/targets/>). Ecosystems with high biodiversity provide important services, such as pollinating cultivated plants and keeping soils fertile. In addition, diverse ecosystems are more stable and resilient under changing environmental conditions, and biodiversity fosters ecosystem adaptability. Finally, biodiversity adds to the quality of human life and to the recreational value of landscapes. Maintaining and increasing biodiversity is thus a major goal in the face of global change.

Habitat loss, land-use change, eutrophication and climate change affect the biosphere and biodiversity on a worldwide scale. Dramatic changes have been observed in biodiversity and ecosystem resilience, as well as in the services that biodiversity provides to human societies. In Switzerland, for example, biodiversity is generally decreasing, although the first signs of stabilization are being recognized, based on the biodiversity research and monitoring conducted at WSL and elsewhere. On a short time-scale, species and communities may react to these environmental changes, and to biotic changes such as biological invasions, in a dynamic way, leading to spatial shifts in the distribution of species or to changes in community composition. On a longer time-scale, environmental change leads to adaptation and alters evolutionary patterns at the species level and above. Changes in biodiversity in response to global change are increasingly being analysed and modelled in order to project future changes, and WSL is at the forefront of this research.

WSL conducts excellent research in the areas of biodiversity monitoring and modelling (both statistical and dynamical), environmental genomics, conservation biology and conservation genetics, mountain and forest biodiversity, and urban ecology. As a federal research institute, WSL focuses its activities on both basic and applied sciences. The latter is crucially important for politics and for cantonal and federal authorities, as well as for implementing practices to protect and foster biodiversity in Switzerland.

Examples of WSL's applied scientific activities in biodiversity include the development of the scientific basis for monitoring and enhancing biodiversity (e.g. action plans for the federal government) and the hosting of national data centres for fungi and lichens, SwissFungi and SwissLichens, which are comprehensive platforms for taxonomic knowledge and the conservation of species in Switzerland. WSL further compiles Red Lists of endangered species and habitats and lists of (and management recommendations for) national priority species for many organismic groups. Other WSL activities focus on the anthropogenic factors influencing biodiversity, such as how forest management affects the diversity of forest organisms. For example, opening up the forest canopy through management practices tends to promote diversification in the herb layer, while promoting dead wood in closed, old-growth forests fosters particular groups of insects and fungi. This research leads to recommendations for enhancing the diversity of plants, animals, fungi, lichens and soil organisms through appropriate management

methods. It also helps with the early detection of negative trends and the derivation of adequate measures for protecting and enhancing biodiversity. WSL additionally develops methods to test, for example using genetic methods, the effectiveness of applied, often costly conservation measures. Some examples are the creation of new habitats such as bogs to increase habitat amount and CO₂ reservoirs, the implementation of stepping stones for endangered amphibians, and the construction of over- and underpasses for vertebrates across motorways to increase connectivity at the landscape scale. Finally, WSL monitors the nationally important habitats of Switzerland mandated by the FOEN. WSL thus contributes to many of the approximately 40 official biodiversity indicators of FOEN and to the international reporting on biodiversity by the federal government of Switzerland.

To align with the efforts of the ETH Domain (see Section 3.1.1) and to further strengthen research, application and outreach in terrestrial biodiversity, WSL set up the WSL Biodiversity Center in early 2020. The vision of the Biodiversity Center is to build a nationally and internationally recognized research and outreach focal point in biodiversity at WSL. Its specific goals are internal capacity building and integration across WSL (e.g. high-profile biodiversity seminar speakers; annual biodiversity research day), outreach and education (e.g. science–practice dialogue, high-profile biodiversity summer schools), and research excellence (e.g. innovation workshops, international symposia, synthesis). By considering applied issues, the Biodiversity Center also focuses on research towards solutions aimed at stakeholder needs and outreach. It particularly integrates contributions from the social and economic sciences.

2.5.4 Natural Hazards

Natural hazards, such as snow avalanches, shallow landslides, rockfall, debris flows, floods and forest fires, cause substantial damage in Switzerland. The property damage per year from floods and mass movements is estimated at over CHF 300 million. In addition, 23 people per year are killed by snow avalanches in the Swiss mountains. Despite large efforts by the Swiss authorities during the last decades to mitigate the effects of natural hazards, hazardous mass movements and floods continue to threaten people and infrastructure. Full protection at all times is beyond reach and in contradiction to a risk-based management approach. Among the challenges related to protection from natural hazards are: (i) the effects of climate change in mountain regions, such as permafrost degradation, on the frequency and extent of mass movements; and (ii) the consequences of anticipated societal changes, for example increasing demand for availability of crucial life lines, such as transportation and communication links. To address these challenges WSL initiated the research programme CCAMM in 2017.

WSL's research and services help protect people and infrastructure from natural hazards. To this end, WSL has established several unique experimental sites to investigate the processes involved in avalanches, rockfall, debris flow and sediment transport in order to improve protection measures and warning systems. WSL researchers are leaders in the areas of snow avalanche formation and dynamics, in particular through the successful combination of experimental and modelling approaches. The most widely used avalanche modelling system worldwide is the Rapid Mass Movements software suite RAMMS developed at WSL. Building on its vast capabilities, models for other mass movements, such as rockfall and debris flows, have been developed to support practitioners in analysing and assessing risks from natural hazards. In addition, remote sensing technologies have recently become increasingly

used in alpine terrain, for instance for snow depth mapping. The knowledge, expertise and experience of WSL researchers in natural hazard mitigation is recognized worldwide.

The prominent involvement of WSL in natural hazards warning and prevention systems was confirmed in the winters 2018 and 2019 when extreme snowfall events caused imminent danger of avalanches for people and infrastructure in the Swiss mountains. Thanks to the successful combination of permanent and temporary mitigation measures, in particular timely warnings, these events were well managed and major damage was prevented. WSL's involvement in these systems includes issuing the well-known avalanche bulletin twice a day during the winter and providing crucial support to federal and cantonal authorities in avalanche and flood prediction. Moreover, WSL researchers studying water shortages are leaders in drought forecasting, exemplified by the web-based information platform drought.ch. Mountain forests, with their protective role against snow avalanches, shallow landslides and rockfall, represent the backbone of natural hazards management. WSL researchers in forest engineering and natural hazards interact closely to study mass movement–forest interactions. In addition, a strong research focus at the WSL Cadenazzo site is on forest fires. Mandated by FOEN, WSL manages the Swiss forest fire database Swissfire, in collaboration with the cantonal forest services, and has developed the Fire-Niche software, a statistical forecasting tool for assessing the risk of forest fires.

2.5.5 Snow and Ice

The cryosphere – snow, ice, permafrost and glaciers in mountains and at the poles – is undergoing rapid changes as it responds sensitively to the atmospheric warming observed over the past century. Snow and ice are of high relevance for Switzerland because of their importance for tourism and hydropower production. Winter sports and winter tourism currently add about CHF 7 billion to the gross domestic product. About 40% of the total runoff in Switzerland results from snow melt, and Swiss electrical energy production attributed to hydropower amounts to 56%. Studying the cryosphere and cryospheric processes and their links to hydrology is the basis for successful natural hazards prevention and warning in mountain regions and for anticipating climate change impacts and developing adaptation strategies.

WSL researchers are leaders in the areas of snow microstructure, snow physics, snowpack stability, snow cover modelling, snow–atmosphere interactions, snow climatology, and snow hydrology. This has opened new opportunities for snow research in polar regions, and WSL researchers are increasingly playing an active role in international expeditions to polar regions, such as in the MOSAiC expedition (Multidisciplinary drifting Observatory for the Study of Arctic Climate). WSL has a unique position with regard to alpine permafrost and snow monitoring. In particular, the long-term data series of snow measurements are the basis for studies in snow climatology that attract growing interest from other researchers and from society. WSL researchers continue to pioneer the study of snow physics, in particular the highly porous nature of snow, by using micro-computed tomography to visualize snow evolution in cold laboratory experiments. These laboratory studies are a prerequisite for the development of microstructure-based snow models describing the mass and energy transfer within the snowpack. In the area of snow hydrology, unprecedented progress has been made over the last ten years. WSL has led the integration of the results of small-scale field studies into large-scale (mountain range) models of snow deposition and melt. In addition, the introduction of modern remote sensing tools has enabled unforeseen major advances in the mapping and monitoring of snow deposition. The amount

of snow depth variation has large implications for runoff prediction and snow avalanche hazard assessment.

WSL is also at the forefront of research on the effects of changes to mountain permafrost on, for example, high-elevation infrastructure. Since 1996, permafrost in the Swiss Alps has been monitored in boreholes equipped with instruments. This permafrost measurement network supplies essential data on the state of permafrost and aids the understanding of the complex interaction between the ground surface and underlying substrates, as well as the effect of snow coverage on permafrost. Since 2000, these permafrost measurements have been an essential contribution to the Swiss Permafrost Monitoring Network PERMOS, which is partly based at SLF. The data obtained are also used in national and international assessments of the state and evolution of mountain permafrost, such as the Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) by the Intergovernmental Panel on Climate Change (IPCC).

WSL has substantially increased its research activities in glaciology through a joint professorship with ETH Zurich and through a new research group, largely funded by an European Research Council (ERC) grant, studying the cryosphere in a changing climate and its impacts on water resources in High Mountain Asia, the Andes and the Alps. WSL research in glaciology ranges from field monitoring and remote sensing of glaciers to the cutting edge of process understanding and model development. In recent high-impact studies involving WSL scientists, the volume of glacier ice on earth and the extent and stage of supraglacial debris have been determined and numerical models have been developed to better predict the response of glaciers to sustained climate warming. Glaciers are also key contributors to mountain streamflow during droughts, and WSL hosts unique expertise in the study of glacierized catchment hydrology in remote mountain areas globally. Additionally, WSL scientists are involved in the development and application of new passive-microwave technologies to assess glacier and ice sheet hydrology at large scales.

Building on its basic research on snow, permafrost and glaciers, WSL generates and applies knowledge in areas of great importance for Switzerland, such as snow and snow water resources, the development of snow management procedures for ski resorts, the impacts of glacier changes on water resources and hydropower production, and the impacts of changes to mountain permafrost on infrastructure, landscape evolution and natural hazards. The research programme CCAMM bundles research on impacts due to changes in the mountain cryosphere.

2.6. Teaching

WSL fulfils its mandate to educate students and specialists in its five thematic focus areas: forest, landscape, biodiversity, natural hazards, and snow and ice. Teaching activities range from courses at ETH Zurich and EPFL, other Swiss universities, universities of applied sciences, and institutions of higher education in Switzerland and abroad, to Massive Open Online Courses (MOOCs) and continuing education sessions for practitioners.

In 2019, WSL staff taught a total of 2,970 hours at universities and other institutions of higher education, a figure similar to that for previous years. The largest share of these hours – about two-thirds – took place within the ETH Domain (ETH Zurich and EPFL: 1,992), while 606 hours were taught at Swiss universities and 237 at universities of applied sciences. The 135 remaining hours were taught at institutions of higher learning outside of Switzerland. These teaching sessions are primarily given at the

Master's and PhD levels. Regarding continuing education, WSL's contributions are mostly in specialist fields, and they supplement existing programmes at institutions of higher education. Having direct contact with Bachelor's, Master's and PhD students is of great importance for WSL, as it encourages students with excellent qualifications to complete their degree theses at WSL. In 2019, WSL researchers supervised 142 Bachelor's and Master's theses and 141 PhD theses. Out of all PhD students supervised by WSL employees in 2019, 57% were matriculated at ETH Zurich and EPFL.

At the end of 2019, WSL employed a total of 25 professors at universities in Switzerland and abroad. Seven of them were affiliated with a university (4 ordinary, 1 associate, 2 assistant professors) and 18 had an honorary professorship, half of which were abroad (Europe, North America, Asia). Finally, three WSL researchers held the academic title of Privatdozent (PD) with a Venia Legendi at the ETH Zurich and at the Universities of Bern and St. Gallen. Several adjunct professorships held by WSL researchers and four joint professorships with ETH Zurich and EPFL, as well as planned future joint appointments (see Section 3.1.3), guarantee that exchange with students is formalized and teaching interests are coordinated between ETH Zurich, EPFL and WSL.

Many WSL topics require knowledge of special expertise and techniques, which is why field weeks and summer and winter schools are key components of WSL's course offerings. A few examples include the European Snow Science Winter School, the International Dendroecology Field Week, and the summer schools of the forest network of research centres located in Nancy, Fribourg and Zurich (NFZ), all of which are organized by WSL and its partners. In addition, WSL experts are regularly invited as keynote speakers and teachers to national and international summer and winter schools, as well as workshops and field courses.

3. Strategic Orientation

Following a WSL-wide strategy process (Section 1.2), the WSL Directorate has defined three WSL strategic initiatives for the planning period 2021–2024: Blue-Green Biodiversity (BGB), Extremes, and the Climate Change and Extremes Research Center (CERC) in Davos. These strategic initiatives represent important development areas for WSL over the coming years covering basic research, research networks, research infrastructure and stakeholder contacts, and they will involve all research and support units (Section 3.1). WSL will also maintain its activities in the five focus areas, forest, landscape, biodiversity, natural hazards, and snow and ice, including the long-term monitoring programmes LFI and LWF, the programmes SwissForestLab, EnviDat and CCAMM, and the Landscape Centre and Biodiversity Center (Section 3.2). The three ongoing programmes SwissForestLab, EnviDat and CCAMM, launched in the previous planning period 2017–2020, cover the establishment of a Swiss research network in forest research, the development of an environmental data portal, and basic and applied research on the topic of climate change impacts in mountains. These programmes have been successfully initiated and run over the past three to four years, and the first key results, tools and products have emerged. A total of CHF 2 million has thus been allocated as funding to each of the three programmes for the second phase. The highly successful research programme Forests and Climate Change came to an end in 2018, and the Energy Change Impact programme will end in 2020. WSL will adapt its current activities or engage in new activities depending on the overall funding situation and the relevance and potential of a particular topic for WSL and for Swiss society and politics.

3.1. New WSL Strategic Initiatives

In the planning period 2021–2024, WSL will promote the three new strategic initiatives: BGB, Extremes, and the CERC in Davos. These initiatives will formally be implemented as WSL programmes, overarching research clusters or, in the case of the CERC, a research centre. These new strategic initiatives are complementary to existing WSL activities, either filling gaps identified in the strategy process or expanding in areas of substantial societal relevance. With the BGB initiative, WSL aims to strengthen its activities in the important area of biodiversity. The BGB2020 and BGB2021–24 joint initiatives with Eawag, supported by the ETH Board, will foster collaboration and support aquatic (blue) and terrestrial (green) biodiversity research activities in the ETH Domain. The Extremes initiative will focus on the effects of extremes on the environment and people, primarily focussing on extremes related to climate change and land-use change but also considering those linked to natural resource extraction and other drivers. By attaching considerable weight to stakeholder involvement, the Extremes programme will be used to develop practical solutions to mitigate the impacts of extreme events and to develop smart response strategies. Finally, with the establishment of the CERC in Davos in collaboration with the canton of Grisons, WSL aims to strengthen its activities in weather and climate extremes and climate change in mountain regions. Two joint professorships with ETH Zurich in the areas of weather/climate extremes and alpine mass movements complement the institutional setup of the CERC. For the first phase 2021–2024, the joint Eawag-WSL BGB initiative has a budget of CHF 6.5 Mio from the ETH Board, the Extremes initiative is financed by WSL with a total of CHF 4 Mio, and the CERC has a total budget of CHF 24 Mio, to which WSL mainly contributes through in-kind contributions.

3.1.1 Blue-Green Biodiversity (BGB)

Biodiversity is essential to human life and welfare, and understanding, managing and protecting biodiversity is critical to achieving sustainable development. Switzerland initiated a national biodiversity strategy in 2012 and conceptualized its measures to maintain and foster biodiversity in the corresponding action plan in 2017. In particular, the Swiss government plans to implement an ecological infrastructure sustaining biodiversity that is analogous to the anthropogenic infrastructure sustaining human society. Internationally, the report from 2019 of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) called for a broader awareness of the importance of biodiversity in politics and the broader public. WSL wants to increase the visibility of its basic, targeted and applied research in biodiversity and its impact in politics and practice.

Freshwater and terrestrial ecosystems and their interface are hotspots of biodiversity. The severe threat to biodiversity in these systems does not receive sufficient attention. A focus on the ecological and evolutionary processes that are common to both terrestrial and aquatic ecosystems and that underlie their interdependency is thus needed. Eawag and WSL are well positioned to fulfil this task and have a successful history of working together (e.g. in river restoration). They have – with the financial support of the ETH Board – initiated two BGB initiatives.

The aim of the BGB2020 initiative is to engage the biodiversity community at Eawag, WSL and beyond. It makes use of existing biodiversity, environmental and remotely sensed data readily available at Eawag and WSL to generate added value through modelling at the interface of aquatic and terrestrial ecosystems and to provide scientifically sound results of relevance for practice, politics and society. In addition, the BGB2020 initiative involves horizon scanning to detect questions of scientific importance and/or high societal or policy relevance in the conservation of biodiversity.

Based on this horizon scanning, Eawag and WSL will use the BGB2021–24 initiative to expand their integrated research efforts in landscapes with interdependent terrestrial and aquatic biomes, reflecting the fact that organisms, resources, chemicals and particles migrate or flow across land–water boundaries. A cohort of postdocs and PhD students will apply novel technical and modelling approaches to understand the processes that create and maintain species, genetic and functional diversity. Relevant questions targeted at generating impact in society and politics will be identified via stakeholder involvement. One example of such a question is the effectiveness of ecological infrastructure along river systems in supporting connectivity in longitudinal and lateral directions. Outreach and transfer efforts will be increased, as they are critical for the effective implementation of conservation measures.

3.1.2 Extremes

Driven by globalization and climate change, the frequency and severity of extreme events will likely increase over the coming decades. For example, many forested stands throughout Northern Switzerland and Central/Eastern Europe turned brown in the middle of the summer 2018 as a reaction to extreme heat and drought. While some impacts can be anticipated, other consequences for the environment and society are still unclear. The WSL programme Extremes will foster inter- and transdisciplinary research to equip Swiss stakeholders with appropriate decision-making tools and coping strategies.

While we have a general understanding of the impacts of extreme events on environment and society, our knowledge on the timing, the specific impacts, and their confounding effects, is more limited. Most impact assessments still rely on a linear scaling of driving effects to projected futures. However, evidence is growing that this approach does not fully capture the mechanisms behind impacts on the environment and society. In fact, dramatic effects will most likely occur in response to abrupt, compounded or interacting changes, and less so to gradual changes of the drivers behind these impacts. The Extremes programme will keep a broad focus on the impacts of extreme events on the environment and society in response to their natural and anthropogenic drivers. As extremes are ubiquitous in the terrestrial environment, expertise will be drawn from all WSL research units and across all five WSL focus areas (forest, landscape, biodiversity, natural hazards, and snow and ice).

The new strategic initiative Extremes will involve a systemic approach, with the aim to strengthen the inter- and transdisciplinary capacity of WSL's research in this area. We aim to expand the portfolio of tools, products and solutions we develop in collaboration with our stakeholders to mitigate and manage the impacts of extreme events. The key research questions addressed include: (i) How can we effectively and accurately assess the mechanisms behind the impacts of extreme events on environment and society? (ii) Which mechanisms and cascading impact chains require improved process studies to enhance our capacity to provide better forecasts and projections? (iii) Which datasets and tools are required by, and need to be developed with and for, national and cantonal stakeholders to better enable them to manage and mitigate impacts and related risks associated with extreme events? (iv) How can we better communicate single, cascading and compounded impacts of extremes to the public?

These and additional questions will be tackled over the four years (2021–2024) within the framework of the Extremes programme. The initiative will stimulate research within WSL and beyond, and will serve as a platform for WSL researchers to actively seek interactions with scientists based elsewhere. The ultimate goal, however, is to provide science-based and mission-driven solutions to stakeholders and the public. The inclusion of stakeholders and the planning of syntheses and user-oriented products will be of utmost importance. National and cantonal stakeholders have already been contacted in order to include their needs and contributions at this definitional stage.

The Extremes initiative will additionally build upon the ongoing research programme CCAMM and to the new strategic initiative CERC at the SLF in Davos. The data produced in the Extremes initiative will be archived and made searchable and available through EnviDat. The strategic initiative Extremes will further seek links to ongoing research projects on extremes in the ETH Domain, such as the EPFL-University of Lausanne initiative ClimAct and the Open ETH+ 2020 EXCLAIM project, and to the technology platform C2SM.

3.1.3 Climate Change and Extremes Research Center (CERC) in Davos

The increasing frequency and intensity of extreme events due to progressive global warming is a prominent aspect of climate change. These changes have the potential to trigger social and economic crises in the Alps, for example by increasing the frequency and impact of natural hazards (e.g. alpine mass movements) or through the loss of previously available ecosystem services (e.g. increased vulnerability of protection forests to disturbances). Effective and efficient handling of natural hazards is of fundamental importance for the sustainable existence of society in mountain regions. In order to cope with

the hazards and risks and to increase the resilience of society, measures in prevention, intervention and restoration are necessary. In the case of rare but massive events, however, the classical approaches to natural hazard management reach their limits and risk communication becomes a major challenge.

With the establishment, in collaboration with the canton of Grisons, of the CERC at SLF in Davos, WSL aims to strengthen its activities in mountain research and gain critical knowledge on the effects of extreme weather and climate events and climate change in mountain regions, as well as providing answers on how society can adapt to these events. Research conducted at the CERC will primarily focus on how the Alps can remain a safe and secure place in the face of global change. The findings can be expected to be exemplary for mountain regions all over the world and to contribute to a better understanding of the effects of extremes and their associated risks in order to find solutions to mitigate or manage them for the benefit of society.

Research priorities of the CERC complement and strengthen existing WSL activities in natural hazard prevention, in particular in view of future challenges related to climate change. The CERC research priorities are: (i) weather and climate extremes in the Alpine region; (ii) permafrost; (iii) remote sensing, early detection and warning; (iv) alpine mass movements; (v) mountain ecology and protection forests; and (vi) risk management, risk communication and resilience. Several of the currently 11 research units of WSL will actively contribute to the development of the CERC, offering exciting new opportunities for enhanced research collaborations at WSL, in particular by capitalizing on the synergies with the existing research programme CCAMM and new initiative Extremes.

Close collaboration with ETH Zurich, through the establishment of two joint professorships in the areas of weather/climate extremes and alpine mass movements, with EPFL, through collaboration with the Alpine and Polar Environment Research Center (ALPOLE) in Sion, and with other research institutes of the ETH Domain, as well as with C2SM, NCCS and the Swiss Federal Office for Meteorology and Climatology (MeteoSwiss), will complement the institutional setup.

The CERC will start its operations on 1 January 2021 and gradually grow over the coming years. The CERC's location at SLF in Davos will help contribute to the centres' national and international reputation. The CERC has been secured financially for the period 2021–2032. The basic financing of approximately CHF 72 million for this 12-year period has been secured through contributions from both WSL and the canton of Grisons, and from ETH Zurich through the two joint professorships.

3.2. WSL Research Focus Areas: Strategic Orientation

The strategic initiatives presented in Section 3.1 build upon the five WSL research focus areas. WSL will continue its activities in the areas of forest, landscape, biodiversity, natural hazards, and snow and ice. Some themes will be strengthened in a targeted manner, as described in the sections below. Depending on the overall funding situation and their relevance in science, society and practice, other themes will be reduced or ended to allow WSL to remain flexible, innovative and competitive.

3.2.1 Forest

WSL will continue research on forest ecosystems and forest management, using monitoring, experimental and modelling approaches, to maintain an internationally leading position. It will focus its activities on several areas of great importance for Switzerland, including the promotion of resilient forests and contributions to a sustainable bioeconomy. Topics of interest include forest dynamics, forest soils, forest health and biotic interactions (including damage caused by wildlife), forest biodiversity, sustainable management and use of forest resources, and multi-purpose forestry from lowland to mountain forests.

Key research fields for WSL are the understanding, characterization, estimation, and modelling of forest resources and their dynamics in the future – both below and above ground – and the provision of forest ecosystem services in a changing environment. The strategic initiative SwissForestLab was successfully initiated with the aim to advance the understanding of the complexity and the functioning of forest ecosystems and their sustainable use. This initiative has been consolidated and acts as a fruitful collaboration and discussion platform, as well as a hub for research initiatives and the joint use of data and infrastructure.

WSL will strengthen its research on the sustainable use of forest resources and multipurpose forestry by exploring the potential and limitations of integrative management approaches that optimize the provision of multiple services, such as wood production, protection against natural hazards and the promotion of biodiversity. Such approaches are becoming increasingly important in a world of growing populations with shrinking resources. Overall, the demands on forest ecosystem services continue to increase, resulting in a greater need for wider coordination to obtain multi-functionality, but also for segregation strategies for prioritization, conflict management and economically efficient implementation. WSL research delivers scientifically robust information, scenarios and strategies to optimize the performance of different forest ecosystem services in the framework of integrated planning.

In the current biodiversity crisis forests are becoming increasingly important hotspots of biodiversity. In a densely populated country like Switzerland, there is an urgent need for concepts of holistic biodiversity management linking conservation and the promotion of biodiversity with other ecosystem services. In the coming years, WSL will foster biodiversity research on specific forest topics, such as integrated management concepts, functional biodiversity (above and below ground), rare species, and specific biomes (e.g. mountain areas and floodplain forests). This will largely be done through initiatives like the SwissForestLab, WSL Biodiversity Center and BGB.

The past decade has demonstrated the dominant effects of environmental extremes, such as storms (Burglind, Vaia), heat and drought waves (2011, 2015, 2018), and subsequent massive bark beetle attacks, but also the occurrence of new pests (e.g. Asian longhorn beetle), new diseases (e.g. ash die-back), and invasive tree species (e.g. tree of heaven), on the resistance and resilience of forests and forest services such as wood production and carbon sequestration. Hence, one research focus of WSL in the upcoming planning period in the area of forest research will be the impact of environmental extremes on forest ecosystems and their management. This will be done within the framework of the new WSL initiative Extremes.

3.2.2 Landscape

WSL will continue research and outreach activities in landscape science during the upcoming planning period, building on a comprehensive and interdisciplinary research approach integrating natural, social and economic sciences. The tools, methods and approaches applied include surveys, interviews, expert elicitation, monitoring, remote sensing, modelling, and studies on territorial and landscape governance.

Research on coupled land systems will be a core topic for WSL in the coming years. Integrated land systems analyses using novel representations of land use and state-of-the-art land-use models will enable comprehensive regional-scale assessments of land-use consequences for society and the environment. Such integrative studies of the interrelationship of societies and their environments will make it possible to explore leverage points for a transition towards sustainability. A particular focus of WSL will be on sustainable agricultural intensification in Europe, an important component of bioeconomy, taking all landscape elements (e.g. hedgerows, water bodies, trees) into account. The use of scenario studies will enable WSL to study the impacts of alternative developments, including extreme events, on landscape sustainability. WSL will also strengthen its focus on individual and collective land-use decision-making in order to better understand past, current and future land use and competing interests with respect to land. Finally, WSL will continue to address people's behaviour and demands regarding landscapes, as well as recreational uses and health benefits of nature.

Another important WSL topic related to landscape sustainability is spatial planning, which is of ever increasing societal relevance. This includes planning settlement areas with integrated green and built-up areas, finding new ways to manage multifunctional landscapes, and preventing and mediating land-use conflicts. As part of this research, WSL will also address opportunities and risks of centralization versus peripheralization of human activities and the built environment.

The current and expected future development in Big Data analysis, remote sensing and digitalization opens up innovative avenues to overcome shortcomings of current land-use models, such as reducing the complexity of landscapes to pixels of dominant land cover type. In order to pursue a true integration of natural and social systems in landscape research, WSL intends to invest in the topics of landscape ecology, spatial biodiversity dynamics and ecological remote sensing by strengthening its competence and knowledge on the modelling, measurement and quantification of processes in vegetation using earth observation data. Close links to the research themes forest and biodiversity, to the new strategic initiative BGB, and to the ongoing programme SwissForestLab are relevant.

WSL will continue its internationally well-known landscape monitoring activities (e.g. LABES), with the goals of ensuring that indicators describe changes in the physical and perceived landscape and measuring the achievement of objectives for various landscape services. A number of additional landscape-relevant topics will be included, namely the influence of landscape quality and the changes in the landscape due to the energy system transformation.

Finally, WSL will continue to support its Landscape Centre. There is a clear demand from stakeholders for landscape research and outreach on a national and international level. WSL is the primary institution in Switzerland that serves this need. WSL plans to strengthen this role, specifically by reflecting the processes of knowledge transfer to stakeholders and supporting the mainstreaming of landscape

into all relevant policies. Specifically, WSL aims to improve the contribution of landscape science to broad environmental and spatial development policies in order to raise awareness, especially outside the already sensitized circle. This task is particularly relevant for addressing the social and environmental challenges of the Anthropocene.

3.2.3 Biodiversity

WSL will continue research and outreach on biodiversity, largely building on the highly successful work completed in past years. In particular, it will showcase the BGB initiative. Biodiversity research at WSL will focus on changes in and the dynamics of biodiversity based on empirical, experimental and functional data, environmental modelling, genomics and transcriptomics, and remotely sensed information on ecosystems. The following research questions will be addressed: (i) How does climate change affect the dynamics of biodiversity, including functional and genetic biodiversity? (ii) What are the measurable consequences of biodiversity loss and dynamics on human society? (iii) How can negative trends in biodiversity dynamics be mitigated? WSL researchers will make use of large empirical datasets on changes in habitats, species communities, species, and species traits and genes. Experimental setups will be of particular relevance.

For the years 2021–2024 a number of research foci in biodiversity have been identified. These research foci align well the BGB initiative. They include: (i) Ecological modelling and forecasting: in the coming years, this modelling capacity will be further developed at WSL to include comprehensive ecological-evolutionary modelling at different spatial and temporal scales. The use of eco-evolutionary modelling in forecasting is an important requisite for the strategic initiative Extremes. (ii) Urban biodiversity and ecology in Switzerland: the importance of green spaces for urban biodiversity and the urban “climate” under climate change, but also for human welfare and health in cities, is becoming increasingly important. Green infrastructure (parks, private and allotment gardens, urban trees and forests) and blue infrastructure (lakes, rivers, brooks) provide relevant future resources for city dwellers. (iii) Modern monitoring techniques in application and practice: one example is environmental DNA (eDNA) in biodiversity monitoring. WSL routinely uses eDNA to monitor amphibian species in the nationally important habitats of Switzerland and to monitor forest biodiversity (e.g. as part of the SwissForestLab activities), for example for the identification of fungi in dead wood in forest reserves. A dedicated state-of-the-art eDNA lab will be established at WSL, and methodological exchange across WSL will be improved through targeted workshops. Another example is automated species identification from images coupled with machine learning, a technique that is revolutionizing biodiversity monitoring. WSL already implements such automated methods, for instance to monitor invasive species along railway tracks from remote imagery.

Finally, WSL recently established the Biodiversity Center, with the aim to build a nationally and internationally recognized research and outreach strength in biodiversity at the institute.

3.2.4 Natural Hazards

WSL will continue research on natural hazards, striving to find solutions that can be applied by practitioners. Research will be focused on predicting when and where mass movements, floods, droughts and forest fires are likely to occur, their likely extent, and how to best mitigate their effects. While the

mass movements and floods are often triggered by extreme precipitation, droughts and forest fires are due to a lack of precipitation.

Research questions that guide WSL's activities in the area of natural hazards include: (i) How will climate change affect the frequency and extent of gravitational mass movements in mountain regions e.g., due to permafrost degradation? (ii) How can we improve avalanche and flood forecasts at various spatial and temporal scales? (iii) How can the lead time of early prediction of drought be extended? (iv) How can we improve the current, widely-used risk-based approach to hazard management, given the ongoing societal changes and the need for greater resilience? (v) How can we develop hazard mapping procedures that consider recent advances in modelling, as well as increased uncertainty due to climate change? (vi) How can we anticipate rarely occurring cascading events (such as the Pizzo Cengalo Bergsturz that triggered debris flows) and decrease their impact by designing adaptable mitigation measures? (vii) How will environmental extremes such as storms, forest fires, heat and drought affect the protective function of forests?

Climate impacts and future societal changes resulting from mass movements in Alpine regions will particularly be addressed as part of WSL's research programme CCAMM and the new CERC in Davos. Research on gravitational mass movements will be focused on the physics of rockfall and debris flows, the interaction between these event types and forests, and the protective role of forests. Hazard mitigation procedures will be improved through research that combines investigations at experimental sites with spontaneous events that serve as case studies, and through the coupling of WSL's remote sensing and experimental sensor know-how with modelling expertise. Based on the next generation of snow models (see Section 3.2.5) and the improved understanding of avalanche formation processes, WSL will enhance its knowledge about avalanche dynamics and short-term forecasting capabilities. Predicting and controlling sediment transport is key to improving erosion mitigation measures and is also highly relevant for managing hydropower facilities. This research focus will allow WSL to strengthen its position as a competence centre for the management of mass movements in mountain regions.

WSL will further develop its drought-forecasting tools, in particular to implement post-processed meteorological forecasts in operations and establish the link between forecasts and impact. The nexus between drought and wildfire offers unique synergies that will make it possible to extend the lead time of early prediction of drought by exploring teleconnections and weather patterns. The forest fire topic involves both individual forests and the landscape (e.g. fuel type and distribution, endangered landscape elements, changes in forest and landscape characteristics). Post-fire dynamics, in turn, imply changes in ecosystem biodiversity and in the risk of natural hazards such as shallow landslides, debris flows and rockfall.

Additional research activities will focus on how to best mitigate the consequences of changes in climate and society in order to improve resilience and adaptation capabilities. As projecting changes in climate and society is inherently difficult and associated with large uncertainties, an improved understanding of the precursors to, for example, imminent mass movements, as well as the processes involved in such events, is needed in order to establish natural hazard warning capabilities that can satisfy the requirements of the future.

To achieve this goal and to improve early warning systems in addition to structural protection, WSL will expand its expertise in the application and testing of new technologies, such as remote-sensing-

based monitoring of potential mass movements and snow resources. Using the results of state-of-the-art numerical weather prediction models and building on its extensive monitoring network, WSL will be able to maintain its internationally leading position in the operational short-term forecasting of snow avalanches, snow water resources, floods and droughts.

3.2.5 Snow and Ice

WSL will strengthen its leading position in research on cryospheric processes including snow, ice, permafrost and glaciers, largely building on its successful, internationally recognized work conducted in past years. This research is focused on advancing scientific knowledge, through laboratory and field investigations, and provides the basis for key applications in addressing climate change impacts. This includes ensuring that WSL can perform its legally mandated forecasting tasks based on robust, state-of-the-art scientific results. To this end, WSL will continue to extend in time its unique long-term snow and permafrost data series. As a founding member of the Swiss Polar Institute (SPI), WSL plans to continue its research in polar regions by building on e.g. the success of the MOSAiC polar expedition.

Snow and permafrost research at WSL is focused on the assessment of how microstructure affects snow physics, the modelling of snow instability, the development of the next generation of snowpack models, and the understanding of changing Alpine snow and permafrost. Glacier research at WSL is focused on field monitoring and remote sensing of glaciers, representing the cutting edge of process understanding and model development.

WSL will strengthen its capability to study cryospheric processes with an integrated approach, combining laboratory and field studies with numerical modelling and remote sensing. Research questions that will guide WSL's activities include: (i) How can we represent physics-based snow and ice microstructure in the next generation of snowpack and glacier models? (ii) How will global change affect mountain permafrost, snow and glaciers, and what consequences can be expected regarding mass movements? (iii) Can numerical modelling of snow instabilities at high temporal and spatial resolutions improve avalanche forecasting? (iv) What are the consequences of the changing mountain cryosphere on water, snow and ice resources with regard to winter sports, tourism, hydropower production and water supply in high mountain catchments? (v) How can we combine remote sensing of snow and cryospheric processes with numerical models, in particular high-resolution weather prediction models, to improve avalanche and flood forecasting? (vi) How can we provide accurate glacier-change projections for the medium and long term, associated changes in water resources, and regional- to local-scale assessments for future glacier-related hazards?

WSL researchers will continue to contribute to annual monitoring of glaciers in Switzerland, thus helping to maintain one of the longest and most complete records of glacier monitoring globally. The unprecedented retreat of glaciers has given rise to the request for fast and updated information on glacier changes. WSL will respond to this need by establishing an operational, near-real-time glacier monitoring platform and by conducting a comprehensive study of debris-covered glaciers. In Switzerland, the operational near-real-time platform is intended to address the need for information, in the context of both water resource management and hydropower operations.

3.3. WSL Contribution to Strategic Focus Areas in the Strategic Plan 2021–2024 of the ETH Board

In its Strategic Plan 2021–2024 for the ETH Domain, the ETH Board decided to continue the three Strategic Focus Areas (SFA) initiated in the period 2017–2020 – Personalized Health and Related Technologies, Data Science, and Advanced Manufacturing – so that their full potential can be realized. Financial resources will specifically be allocated to research in these areas. In a subsequent decision, the ETH Board elevated the topic Energy and Environment to the level of an SFA.

Given its thematic focus and expertise, WSL will contribute to the SFA Data Science. No specific contributions are expected for the SFAs Personalized Health and Related Technologies or Advanced Manufacturing, though WSL does work in related areas and will contribute on the project level where appropriate. In contrast, all WSL work is relevant for and contributes to the SFA Energy and Environment, as summarized below.

3.3.1 Data Science

In 2016, the ETH Board launched the initiative for Data Science in Switzerland to accelerate data science, both through the expansion of education and research and through the provision of infrastructure for data science users across disciplines. The aim of this initiative is to foster collaboration among top institutions, and it will include the exchange of best practices in curriculum development and joint data science, as well as Big Data research projects.

As part of this ETH Domain initiative, EPFL and ETH Zurich have jointly launched the Swiss Data Science Center (SDSC). The SDSC “will address the fragmentation within today’s data and analytics landscapes”. The centre brings together a distributed multidisciplinary team of data scientists and experts in a range of domains, including earth and environmental sciences.

WSL is committed to actively contributing to the ETH Domain activities related to the SFA Data Science and the SDSC. Since the launch of the SDSC, WSL has collaborated on four scientific projects funded through the regular SDSC annual calls, thereby covering a diverse set of topics including species biodiversity analyses; data mining; deep learning for biodiversity detection and classification; combining machine learning, ecological modelling and plant morphological characteristics to develop a tool for identifying plants in Switzerland; and snow avalanche forecasting by data-driven automated predictions. In the future, WSL intends to strengthen its expertise in data science through collaborative projects with the experts from SDSC. The long-term environmental datasets hosted at WSL and largely accessible through the environmental data portal EnviDat can serve as a testbed for SDSC when searching for opportunities to demonstrate how actionable insights can be derived from diverse sources of data.

Digitalization offers new opportunities for climate and environmental research, monitoring and protection. WSL will contribute to the overarching topic of digitalization through its scientific contributions in the field of the terrestrial environment, such as the digitalization of forest processes and management, landscape monitoring and avalanche warning. New technologies will also help us to guide environmental policies and decision-making by providing efficient and smart access to environmental re-

search data at high temporal and spatial resolutions. Examples include comprehensive life cycle assessments, as well as energy and carbon consumption and footprint calculations in a range of topics, technologies and services.

3.3.2 Energy & Environment

WSL contributes with all its activities to the SFA Energy and Environment, in particular the “environment” part. WSL’s overall mission is to: (i) explore the dynamics of the terrestrial environment, and the use and protection of natural and cultural habitats; (ii) monitor forests, landscapes, biodiversity, natural hazards, and snow and ice; and (iii) develop, in cooperation with its partners in science and society, sustainable solutions for socially relevant issues. The three new WSL strategic research initiatives of the planning period 2021–2024, BGB, Extremes and the CERC in Davos, are examples of how WSL launches targeted initiatives to quickly respond to societal needs in the area of environment and sustainability.

For the “energy” part of the SFA Energy and Environment, WSL will continue to contribute profound and timely information on undesirable side effects of the Swiss energy transition on a project level. These activities were initiated as part of the WSL programme Energy Change Impact, a joint effort of the WSL and Eawag, which will run until the end of 2020. The programme includes, for example, forecasts of the availability of natural resources, such as water for hydropower, and on suitable locations, for example when planning new wind turbines. WSL’s future contribution will be firmly based on research capacities and networks built up during the past few years in the Energy Change Impact programme. As such, WSL researchers are part of a first project consortia that submitted large-scale projects to the 1st Call of the new energy research funding programme SWEET (Swiss Energy Research for the Energy Transition) hosted by the Swiss Federal Office for Energy (SFOE).

Apart from these activities, numerous projects related to renewable energy are ongoing or planned.

4. Goals and Actions According to the Strategic Development Goals 2021–2024 of the Federal Council for the ETH Domain

WSL supports the nine strategic development goals assigned to the ETH Domain by the Federal Council. Contributions to these goals build on WSL's mandate described in Section 2 and on the strategic plan laid out in Section 3. WSL's contributions are organized according to the ten core sections of the performance agreement between WSL and the ETH Board. All WSL contributions presented here are well embedded in the overall WSL strategy and fit with its position in research and society in Switzerland.

4.1. Teaching

“The ETH Domain offers first-class and attractive teaching by any international standard.”

In the planning period 2021–2024, WSL will maintain a high level of teaching involvement, both in terms of content and quality and in terms of total teaching hours. Teaching activities will be diverse, including courses at ETH Zurich and EPFL, universities, universities of applied sciences, and institutions of higher learning in Switzerland and abroad, as well as MOOCs and continuing education for practitioners as part of life-long learning. Teaching evaluation and quality control will continue to be secured through the well-established university systems.

At the university level, the emphasis of WSL's teaching activities will be on thematic contributions in areas where WSL leads at the national or international level and where its scientists hold unique research and teaching skills for basic and advanced training of scientists, engineers or specialists in federal, cantonal and municipal administration and in industry. Teaching areas will include the five focus areas of WSL, i.e. forest, landscape, biodiversity, natural hazards, and snow and ice. The teaching portfolio of WSL will also include workshops, field courses, and summer and winter schools. In the planning period 2021–2024, teaching foci will be in areas where WSL already shares joint professorships with ETH Zurich and EPFL, such as climate and cryosphere, snow and microclimatology, glaciology, and landscape ecology; where joint professorships with ETH Zurich are planned in the context of the CERC, i.e. permafrost, mass movements, and climate change impacts in mountain regions; and where WSL scientists (including adjunct professors and PDs) hold formal teaching responsibilities at ETH Zurich, EPFL and other Swiss universities.

WSL's teaching contributions currently additionally include teaching activities at universities of applied sciences. In the upcoming planning period, these teaching activities will, on the one hand, be focused thematically and where WSL can provide substantial expertise, as is the case for university teaching. On the other hand, WSL teaching at universities of applied sciences will overall be driven more strongly by demand, i.e. where WSL contributions are required and formally requested. In the upcoming planning period WSL will also offer continuing education courses at the university and non-university level for a wide range of practitioners, such as natural hazard managers, foresters and nature conservation officers.

The number of supervised Bachelor's, Master's and PhD students at WSL will be held at current levels for the 2021–2024 period, i.e. at about 230 students per year overall, including both students on WSL payroll and those not on WSL payroll but (co-)supervised by WSL employees.

4.2. Research

“The ETH Domain maintains its leading international position in research and continues to develop its instruments and mechanisms for early identification of future research needs.”

WSL addresses the use, management and protection of natural habitats and cultural landscapes, acting as a bridge between science and the application of research results in the area of terrestrial environments. WSL will maintain its leading position in national and international research in several thematic focus areas and will promote the following three new strategic initiatives in the planning period 2021–2024: BGB, Extremes, and CERC in Davos. Each of the strategic initiatives has been allocated initial WSL funds to support a fast and effective start of the new activities. WSL will also continue its successful programmes initiated in the previous planning period, SwissForestLab, EnviDat and CCAMM, the long-term monitoring programmes LFI and LWF, as well as many other successful longer-term monitoring and research activities. To stimulate innovative ideas in research and application, WSL will continue its practice of allocating a pool of seed money for the launch of especially innovative internal projects.

WSL will maintain its excellence in providing modern working conditions, for example in terms of infrastructure, working time models and gender equality. It will continue to strictly adhere to and actively promote the principles of scientific integrity and ethical guidelines, thereby providing an inspiring scientific environment and enabling cutting-edge research. National and international collaborations will be especially encouraged. A data policy and the environmental data portal EnviDat will continue to ensure long-term access to WSL’s environmental research data.

We refer to Section 3 for details regarding WSL’s specific strategies and research plans for the planning period 2021–2024.

4.3. Research Infrastructures and Large-scale Research Projects

“The ETH Domain develops, builds and operates research infrastructures.”

In the upcoming planning period, WSL will continue to operate a range of research infrastructures of national importance across Switzerland and to manage the related data. Its comprehensive environmental research network includes more than six thousand monitoring sites and dozens of experimental platforms for studying forests, biodiversity, landscapes, natural hazards, and snow and ice. In the areas of forest and snow research, unique time-series data from some of these sites span more than 100 years.

Examples of research sites of international relevance include the snow field on Weissfluhjoch, which hosts a unique snow data series extending over 80 years, and the Swiss alpine remote sensing test site Davos Laret, both of which belong to the World Meteorological Organization’s (WMO) Integrated Cryonet Cluster Davos; the Stillberg afforestation site in Davos, where WSL researchers study the growth of trees at the treeline and the interaction between the trees, snowpack and avalanches; the avalanche test site in Vallée de la Sionne, which is used to assess avalanche movement; the debris flow observation station Illgraben, which is equipped with sensors to investigate the flow behaviour of debris flows; the hydrological test site in Alptal, where innovative methods are used to measure sediment transport in streams; the 19 permanent monitoring sites of LWF; and the measuring station Seehornwald in Davos, which is now an officially certified site in the European infrastructure network ICOS Research Infrastructure dedicated to standardized measurements of greenhouse gases across Europe.

These monitoring sites are complemented with various long-term experimental platforms distributed throughout Switzerland, which include data series extending back over a century. In addition, the experimental forest site Pfynwald and the WSL Model Ecosystem Open-top Chamber facility (MODOEK) in Birmensdorf enable detailed studies of factors influencing plant growth under semi-controlled field conditions.

Additional examples of WSL's high-level research infrastructure that will remain intact in the 2021–2024 period include: (i) The Plant Protection Laboratory for safety levels 1 through 3 at WSL's headquarters in Birmensdorf. This lab was created through a joint effort with FOEN and FOAG. Apart from research purposes, the lab was established to support the Swiss federal government's efforts to diagnose plant pathogens and invasive neobiota that damage Switzerland's forests and non-forest habitats. The Plant Protection Laboratory also includes a high-pressure lab equipped to analyse low-concentration ancient DNA in a safe environment. (ii) The state-of-the-art stable isotope laboratory was established at WSL in Birmensdorf by joining the infrastructures and expertise of WSL and PSI. In addition, the WSL Central Laboratory provides support in the preparation, measurement and analysis of diverse samples. (iii) The cold laboratory at SLF in Davos comprises facilities for micro-computed tomography (micro-CT) and for the production, using snow breeders, of artificial snow that is identical to natural snow. (iv) The internationally well-known tree-ring and wood anatomy lab, where WSL researchers apply a wide range of approaches to quantify the impacts of environmental stressors on tree growth, structure and function, and to reconstruct climate variability.

The existing research infrastructure at WSL will be maintained regularly and optimized as appropriate and necessary to ensure the highest standards. As part of its national and international collaborations, WSL will offer its research infrastructure to researchers from various disciplines from Switzerland and abroad. Where considered useful, WSL will continue to support external research infrastructure, for example at ETH Zurich. An example of a successful collaboration between ETH Zurich, Eawag, WSL and other partners is the Genetic Diversity Centre (GDC) at ETH Zurich, a technology and service platform of the ETH Zurich Department of Environmental Systems Science. Long-term access to and scientific benefit from the rich data pool at WSL will be ensured through the WSL data portal EnviDat.

4.4. Knowledge and Technology Transfer

“To strengthen Switzerland's innovative strength and competitiveness, the ETH Domain promotes co-operation and exchange with the economy and society.”

WSL is primarily concerned with public goods, such as forests, biodiversity, landscapes, and snow and ice, and this focus will be maintained in the 2021–2024 period. It has a long tradition in collaborating with society, such as through the collection of data on the environment. One recent successful example is the publication of a compendium of the flora of the canton of Zurich (Flora ZH), which heavily relies on citizen science. Until now the transfer of knowledge from WSL has mainly been targeted at public authorities, but a broader dissemination of knowledge is envisioned for the coming years. Various federal offices – primarily FOEN, but also the Federal Offices for Civil Protection (FOCP) and for Spatial Development (ARE) – as well as numerous cantonal and municipal offices, from forestry departments to offices for soil protection, will continue to benefit directly from the expertise, teaching, findings, publications and extensive consultation activities of WSL and its employees. WSL will also actively seek

to transfer knowledge and technology to business partners, ranging from small and medium-sized enterprises (SMEs; including many consultancies) to industry, for example through projects funded by Innosuisse.

Examples of WSL knowledge transfer that will continue in the coming years include: (i) Jointly funded and managed research programmes and projects, such as the WSL-FOEN research programme Forest and Climate Change; the research programme RAMMS, resulting in a software package developed at SLF that allows avalanches, debris flows and rockfall to be evaluated and facilitates assessment of the effects of protection measures; the open source snow cover model SNOWPACK, which is used worldwide by avalanche warning services and researchers alike; and the EU-project PROSNOW, where scientists from the SLF and other institutes develop a web-based platform for ski resorts, providing local forecasts of weather and snow cover for their snow management. (ii) Expert assessments and consultations related to natural hazards, such as avalanche accident reports. (iii) WSL Practical Guides (*Merkblatt für die Praxis* issued in the national languages German, French and sometimes Italian), a series of publications that build on WSL research activities and are frequently read by forestry, nature conservation and spatial planning experts. (iv) The Landscape Centre and the new Biodiversity Center, which disseminate knowledge on landscape and biodiversity research nationally and internationally and form a link between researchers and partners in practice, such as government agencies, cantons, cities, NGOs and professional associations. (v) The FORUM für Wissen, an annual event targeted at practitioners that is carried out by WSL in Birmensdorf and Lausanne. The FORUM für Wissen is a topical day dedicated to summarizing research and application on a given issue of practical relevance.

WSL will also continue to offer various software programmes, online tools, courses and advisory services that benefit the federal and local authorities, as well as engineering, planning and environmental offices and winter sports regions, helping them to provide their services in an economical and reliable way. Examples include: (i) the international information and communication platform *waldwissen.net*; (ii) the common information platform for natural hazards GIN; (iii) the NCCS; (iv) Swissfire, the forest fire database of Switzerland; (v) the Datacenter Nature and Landscape DNL, which integrates all of FOEN's data on biotopes and species; and (vi) the EconoMe online risk assessment tool, which supports decision-making where protection actions against gravitational processes, including avalanches, debris flows and rockfalls, need to be taken.

4.5. National Cooperation and Coordination

“The ETH Domain plays an active role in shaping the Swiss higher education area.”

Cooperation and coordination at the national level are of great importance for WSL. Many collaborations with partners from the ETH Domain result in synergies and increased efficiency. All the involved institutions, including WSL, benefit substantially from these collaborations, even when additional coordination costs and efforts are accounted for. Examples of successful collaborations that will extend into the coming planning period include Lib4RI, the shared library of the four research institutes in the ETH Domain; Bau3FI, the joint Empa, Eawag and WSL construction and renovation department; joint ETH Domain research institute software acquisitions and implementation, such as SAP (systems, applications and products in data processing); joint ETH-Domain information and communication technology projects, such as SCION (Scalability, Control, and Isolation on Next-Generation Networks), and joint activities and planning in the area of information security; and the GDC (see Section 4.3). Important

joint projects within the Swiss higher education landscape include the Eawag-WSL strategic initiatives BGB and SwissForestLab.

In the planning period 2021–2024, WSL will continue to support joint professorships with ETH Zurich and with EPFL. The four existing joint professorships have brought WSL closer to the two ETHs in terms of research and teaching. With the establishment of the new CERC in Davos, WSL will further strengthen its cooperation with ETH Zurich through two new joint professorships. Additionally, close teaching collaborations with other Swiss universities and universities of applied sciences will be maintained through an increasing number of adjunct professorships, lectureships, and associate/affiliate scientist positions.

WSL is a co-founder of the SPI, an interdisciplinary centre devoted to studying the Earth's poles and other environments of extreme cold, including high alpine regions. The SPI, based at EPFL, is a consortium of Swiss research institutions – EPFL, WSL, ETH Zurich and the Universities of Bern and Lausanne – and was co-founded by Editions Paulsen, a publishing house specialized in travel and exploration literature. Officially supported by the State Secretariat for Education, Research and Innovation (SERI), the SPI is a Swiss initiative with a decidedly international mission. WSL will continue to contribute to the SPI through its expertise and research in cold environments in the upcoming planning period.

Finally, WSL is part of a number of important national initiatives and committees to which WSL will continue to contribute. Examples include: (i) membership in the BSTB, which directs the federal measures for managing incidents leading to an increase in radioactivity and biological, chemical and natural events; (ii) participation in the LAINAT steering committee; (iii) membership in the NCCS; (iv) participation in the national extra-parliamentary committees on noise control and on spatial planning; (v) the Forum Landscape, Alps, Parks FOLAP of the Swiss Academy of Sciences (SCNAT), where a WSL scientist presides; (vi) the Swiss Biodiversity Forum of the SCNAT, where WSL has a strong presence in the scientific advisory council; (vii) the Swiss Plant Protection Service, where WSL is responsible for diagnosing forest pests and pathogens; and (viii) participation in the Swiss Expert Committee for Biosafety (SECB), a permanent federal advisory committee that advises the Federal Council and the federal agencies on the drafting of laws, ordinances, guidelines and recommendations.

4.6. International Positioning and Cooperation

“The ETH Domain will continue expanding its cooperation and networking with the world's leading institutions and strengthening its international reputation.”

WSL researchers maintain a worldwide research network, with close collaborations across all five continents. The vast international cooperation is well reflected in WSL's publication record: in 2019, WSL researchers published ISI papers with colleagues from 87 countries.

In the coming years, WSL will continue to actively promote international partnerships. When useful for facilitating and fostering scientific collaboration, more formal cooperation will be considered, for example through memorandums of understanding (MOUs). WSL currently has 19 active MOUs with institutions from 10 countries. Regular visits by scientists from these institutions as guest researchers at WSL and vice versa will continue to help foster collaboration and new research initiatives. Recently, an MOU was signed with the Third Pole Environment (TPE) programme in China, which is supported by the Chinese Academy of Sciences and associated with both UNESCO-UNEP-SCOPE and the WMO.

Regarding Europe in particular, WSL researchers collaborate with colleagues from many of the most renowned European research institutions in the field of environmental sciences. When it is of particular strategic importance for WSL during the 2021–2024 period, individual researchers will be supported in actively engaging in international collaborations (e.g. IPBES, IPCC, WMO), societies (e.g. European Space Agency (ESA), European Geoscience Union (EGU), International Association for Landscape Ecology (IALE), and research networks³). In addition, WSL will continue to offer its scientists the possibility of international sabbaticals. In order to ensure the top level of its research, WSL will openly advertise positions and recruit young researchers internationally.

To further strengthen WSL's international collaborations during the coming years, the institute will extend the WSL Fellowships programme. The programme is intended to allow experienced international researchers to spend several months as visiting researchers at WSL in Birmensdorf, Cadenazzo and Lausanne or at SLF in Davos. Founded in 2014, the WSL Fellowships are now well known in the scientific community. So far, this successful programme has brought 28 international fellows to WSL.

WSL researchers regularly participate in international efforts and expeditions. For example, WSL recently contributed with several researchers to the MOSAiC expedition to the Arctic. MOSAiC was the largest-scale Arctic research expedition ever, with a total of 600 people involved on site. Continued involvement in such activities is anticipated for the upcoming planning period.

4.7. Role in Society and National Tasks

“The ETH Domain maintains a dialogue with society and performs tasks in the national interest.”

WSL provides the public with essential information and decision-making support for sustainable resource management, for evidence-based protection of nature, for land-use and landscape development, and for dealing with natural hazards. It develops sustainable solutions for socially relevant problems, in collaboration with its partners from academia, society, authorities and industry. To this end, in the planning period 2021–2024 WSL will maintain an intensive dialogue with a range of stakeholders, including the public administration, representatives of the private sector, NGOs and/or political parties, and it will continue to perform an extensive suite of expert consulting activities.

In order to reach and inform the public about its activities, WSL will continue to have a regular presence in different media and in discussions with interested individuals and representatives from a range of organizations and institutions. The overall number of WSL media contributions per year is currently between roughly 1,600 and 2,400 in print and up to 700 radio or TV broadcasts, and continuation of this large presence is foreseen in the coming years.

Examples of high-impact WSL products that will be maintained during the planning period 2021–2024 include WSL's magazine DIAGONAL and the news sections on the WSL and SLF internet sites. New studies, findings and projects, as well as insights into the processes of research (blog “Logbook”), are presented on the websites on a more or less weekly basis (in German, English, French, Italian). The freely available magazine DIAGONAL is issued twice a year in English, French and German. It includes

³ Example networks include: European National Forest Inventory Network (ENFIN), European research group EVOLution of TREES as drivers of terrestrial biodiversity (EVOLTREE), Global Land Project (GLP), GCOS, International Association of Cryospheric Sciences (IACS), International Union for Conservation of Nature (IUCN), IU-FRO, LTER, NFZ, UNECE-ICP Forests.

articles that go beyond current, short-lived news and illuminate WSL topics in depth. Furthermore, an active WSL twitter account (@WSL_research), with currently over 2,500 followers, and the two Facebook accounts WSL_research (2,200 fans) and WhiteRisk (8,500 fans, dedicated to avalanche accident prevention) enable direct interactions with the public. Both for the website and for the social media accounts an increasing number of short videos will be produced to meet the requirements of consumers.

Additional important contributions of WSL that will continue in the coming years are the countless talks and excursions for non-academic audiences organized and carried out by WSL staff throughout the year in all parts of Switzerland, including guided tours for 3,500 persons per year at SLF's campus in Davos and roughly 400 in Birmensdorf. Finally, WSL will continue to actively engage with the younger generation in order to spread its enthusiasm for science. For example, the institute will open its doors to school children in 5th to 7th grade during the national future day (Nationaler Zukunftstag), offer a summer camp and several one-day programmes during holidays (Ferienpass), and maintain www.wsl-junior.ch, a website targeted at school children and teachers in the lower and upper secondary levels (Sek I and Sek II). WSL will continue to represent an out-of-school place of learning where young students can meet researchers and learn about scientific work. Teaching units which are in line with the biology curriculum (Lehrplan 21) are already available and will be maintained in the future so that teachers can elaborate on particular topics in the classroom. All of these anticipated communicative activities are based on WSL's communications strategy 2021–2024. Special efforts will be made to reach people who are not particularly interested in science per se.

The many national tasks of WSL are described in detail in Section 2.3. WSL will continue to fulfil its mandates throughout the planning period 2021–2024.

4.8. Sources and Use of Finances

“The ETH Domain will expand its financial base and ensure that funds are used in a strategic and economical manner.”

To further increase efficiency, possibilities for cooperation within the ETH Domain, in particular with the other three research institutes, are regularly evaluated by WSL, considering also the costs of coordination. Opportunities deemed favourable will be implemented systematically in the upcoming planning period (e.g. joint purchasing, joint software acquisition and implementation, Lib4RI, Bau3FI, GDC).

WSL remains committed to maintaining the current level of third-party funding in its budget. In the long run, stabilization of these funds at about 30% of the total budget is feasible as long as indirect costs are covered by external funders at the current extent. Higher percentages of third-party funding will only be feasible if indirect costs are fully covered by such funders (see Section 5.1).

WSL will remain dedicated to supporting and protecting the independence of its researchers from public and private funders, customers and partners.

4.9. Real Estate Management and Sustainability

“The ETH Domain – led by the ETH Board as the federal government’s construction and real estate body – coordinates the management of land and real estate owned by the Confederation and ensures that they retain their value and function.”

WSL’s management of properties and real estate is focused on ensuring that both value and functionality are maintained in the long term (see Section 5.3). During the planning period 2021–2024, the maintenance and availability of real estate and infrastructure will continue to be accomplished in compliance with legal requirements. Maintenance and repair work will be organized in such a way that research needs are respected as much as possible. WSL will continue to aim for the highest-level energy and environmental standards in its real estate and infrastructure, such as through the switch to renewable energy for heating whenever possible. In addition, WSL will strive to minimize its environmental impact in all its activities through, for example, a fuel-efficient car fleet, new travel regulations aiming to reduce travel-related greenhouse gas emissions, and an increased focus on environmentally friendly and sustainable food products in its canteens.

In the past years, WSL has succeeded in increasing the total amount of competitive third-party funding (e.g. SNSF and EU projects). This gratifying development resulted in an increase of the total number of WSL employees. For the next years, WSL expects this trend to continue, also as a result of the three newly launched strategic initiatives for the planning period 2021–2024 (Section 3.1). To accommodate the additional space requirements, WSL plans to replace old workshop buildings in need of renovation in Birmensdorf and Davos with larger buildings. Planning of the new workshop building in Davos (D-Trakt) is already in an advanced stage, and construction is intended to start in early 2021. Planning for the new workshop building in Birmensdorf has been initiated and construction is planned to start in 2023. Towards the end of the period 2021–2024, planning of the renovation of the lab building (Laborgebäude LG) in Birmensdorf will be initiated (see Section 5.3).

Most WSL buildings and facilities are constructed in such a way that access and use by disabled persons is neither obstructed nor impeded. The new constructions (described above) will adhere to these accessibility standards.

4.10. Working Conditions, Equal Opportunity and Young Academics

“The ETH Domain is an attractive and socially responsible employer.”

During the planning period 2021–2024, WSL will continue to offer attractive employment conditions, for example by providing flexible working hours, enabling part-time work at all hierarchical levels, and actively encouraging home-office arrangements. WSL will remain committed to evaluating overall working conditions on a regular basis to improve conditions for people with diverse backgrounds and special requirements. A regular wage equality analysis by an independent external provider, already in place, will ensure fair compensation. WSL will continue to promote an inspiring, motivating and safe work environment, following the principle of equal opportunities for all groups of employees. To ensure a non-discriminatory and inclusive culture, WSL will continue funding a position in Institutional Development and Diversity.

WSL will remain actively involved in training young academics and young administrative and technical apprentices. While the number of apprentices at WSL currently varies between 10 and 15, the total

number of students in training (i.e. Bachelor's, Master's and PhD students) is about 230 per year. All PhD students at WSL have access to a PhD club, which offers coaching by a senior scientist, as well as activities targeting PhD-specific needs like research-oriented training, intra- and interpersonal skills coaching and networking. Additionally, WSL conducted a job application workshop for PhD students and postdocs in 2020 as a pilot project, and based on its great success, WSL will continue to run it in the coming years. The workshop will support PhD students and postdocs in their job search in science or private industry and provide information about the relevant job market, application documents and interview situations.

WSL fosters gender balance, especially in leadership and executive positions. At present, the gender ratio at the PhD and postdoctoral levels is almost balanced, whereas at the researcher and leadership level and in executive positions the percentage of women is slightly over 20%. In 2017–2020 WSL developed a Gender Action Plan stipulating targets, strategies and measures to improve the gender balance. Measures fall into four general areas: recruitment process, career support, integration of career and family, and additional measures. The current WSL Gender Action Plan will be revised, if needed, in the planning period 2021–2024 and represents a major step towards formally embedding the gender strategy into the institutional processes.

Furthermore, WSL plans to build on the experiences and findings from the unconscious bias training completed in 2020. Other intentions for the 2021–2024 period are: to further develop comprehensive key figure management and process monitoring, for example for tenure track positions; to monitor gender equality, especially on higher career levels; to finance and support the network of female scientists that originated from the first peer mentoring group of the Fix the Leaky Pipeline programme; and to apply for further programme funding in 2021–2024.

5. Implementation Plans

5.1. Financial Strategy

5.1.1 First-party Funding / Base Budget

The WSL development plan builds on the information available from the ETH Board regarding the overall funding for institutions in the ETH Domain for the period 2021–2024. WSL anticipates an increase of 1% in base funding by the federal government for the 2021–2024 period relative to the year 2020. Additional funding may become available for targeted initiatives through the ETH Board.

To remain flexible, innovative and competitive, WSL will retain its potential to invest in a targeted set of innovative projects and strategic initiatives. This will be achieved by: (i) investing free reserves built up for this particular purpose in the past and (ii) continuously sunseting or cutting back research activities where the goals have been achieved.

Financing of the three new WSL strategic initiatives has been secured until at least 2024: the joint Eawag-WSL BGB initiative has a budget of CHF 6.5 million until 2024 from the ETH Board; the Extremes initiative is financed by WSL, with a total of CHF 4 million until 2024; and the CERC, with a total budget of CHF 24 million for 4 years (and CHF 72 million for 12 years), will receive a WSL contribution until 2024 of about CHF 12 million, mainly through in-kind contributions. Another CHF 2 million has been allocated by the Directorate to the 2nd phase of each of the three strategic initiatives, starting in the previous planning period. The individual budgets for the initiatives will be approved by the WSL Directorate once detailed project or programme plans have been developed.

5.1.2 Third-party Funding

Up to 2020, the FOEN financed 50% of the costs of avalanche warning, with an annual contribution to WSL of CHF 2.7 million. From 2021 onwards, the confederation will transfer this amount into the budget of the ETH Domain and ultimately to WSL. With this transfer of money from third-party funding into the base budget of WSL, the share of third-party funding will be lowered from 32% in 2019 to about 28%. Based on the recent successful acquisition of major projects (e.g. the new CERC in Davos and three ongoing ERC grants), WSL is optimistic that it can achieve an overall share of third-party funding of about 30% over the period 2021–2024.

5.2. Human Resources Strategy (HR)

5.2.1 Personnel Policy

With three new strategic initiatives being launched, WSL expects an increase in the number of employees in the planning period 2021–2024 of about 5%, with 40 new positions at the CERC alone. This is similar to the increase in the previous planning period. As these initiatives will be financed partly through the WSL base budget and partly through third-party funding, both positions funded by WSL and those with third-party funding are expected to increase in number. At the same time, WSL is entering into a period with a large number of upcoming retirements. WSL will thus be recruiting a comparatively large number of new short-term and long-term employees in the coming years. However,

WSL will face the challenge to further develop the scientific and technical profiles of its employees and to keep the balance between people working mainly in basic science and those working in application, knowledge transfer and outreach. To incorporate these different aspects into the recruiting process, the WSL Directorate has determined that all positions lasting longer than one year have to be recruited using committees. As in the past, the WSL Directorate will steer both the profile and work orientation of permanent staff, as all permanent positions have to be approved by the Directorate.

5.2.2 Personnel and Organizational Development

WSL will continue to promote an inspiring and motivating working environment and remain an attractive employer, while still taking into account the budgetary situation foreseen for the planning period 2021–2024. Career development and transition planning will be an integral and important part of the Management by Objectives (MbO) process and will help ensure transparent communication about possible internal and external career opportunities. The tenure-track approach, which involves the open announcement of strategic, long-term research positions at WSL, is designed to maintain transparency regarding long-term opportunities in research. WSL will develop this approach further in the new planning period.

WSL will continue to offer attractive employment conditions and facilitate reconciliation of work, career and family with a range of measures, including flexible working time, part-time work opportunities at all hierarchical levels, and home-office possibilities.

Life-long learning, both on and off the job, will remain an important focus of WSL in the new planning period 2021–2024. WSL therefore will continue to promote a continuing process of education and to support, to the greatest extent possible and within the institutional framework, the career development of employees from all areas of work within WSL, including support and technical personnel. In accordance with the education and training regulations that came into force in 2020, WSL will support adequate education and training, with a cost contribution of up to 80%. For the next planning period 2021–2024, leadership development will be particularly strengthened through a series of specific training measures on leadership competencies. WSL will continue to work together with PSI to offer a Certificate in Advanced Studies (CAS) in Leadership in Science at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW), aimed at employees with managerial responsibilities in scientific-technical environments.

5.2.3 Equal Opportunity

WSL is an equal opportunity employer and is committed to evaluating overall working conditions on a regular basis to improve conditions for people with diverse backgrounds and special requirements. The percentage of women employed at WSL in scientific positions up to the postdoctoral level is above 40%. Even though the number of women in leadership positions has increased from about 15% to more than 20% over the past years, numbers are still low in senior leadership and executive positions. WSL is committed to putting a strong emphasis on and supporting female scientists, in particular those completing their PhD or in the early phases of their postdoctoral research. WSL strives for institutionally embedded processes to promote the presence of female employees in senior leadership and executive positions. Various measures have been developed to improve this situation, most of which are

summarized in the WSL Gender Action Plan. Finally, WSL aims to integrate career planning more closely into the MbO process in the coming years.

5.3. Real Estate Strategy

5.3.1 Existing Buildings

WSL's property and real estate management focuses on maintaining both value and functionality in the long term. WSL currently owns and manages buildings worth roughly CHF 110 million. The maintenance and preservation of these buildings at the current level is essential and helps avoid substantial cost implications later on. Overall, WSL plans to continue spending roughly CHF 4 to 5 million per year on building maintenance and adaptation to new or changing needs.

5.3.2 Planned Buildings

To accommodate the increase in staff detailed in Section 5.2.1, WSL foresees a replacement of former workshop buildings with bigger multipurpose buildings in both Davos and Birmensdorf. Planning for the new building in Davos (Trakt D), which will host the new mechanical lab and contain additional office and storage space, is already in an advanced stage and construction will start in 2021. In Birmensdorf, planning has been initiated and completion of the building is foreseen for 2023 or 2024. For each building, costs of about CHF 7 to 9 million are expected. With these new buildings, WSL will ensure modern, well-equipped offices and mechanical labs to provide necessary services for the snow, ice and avalanche research at SLF in Davos and for all other core research fields of WSL in Birmensdorf. The highest energy standards will be applied in these construction projects. This includes a facade with photovoltaic panels in Davos, which will additionally serve as protection against direct sunlight.

5.4. Information and Communication Technology Strategy (IT)

WSL's Information and Communication Technology (IT) strategy is based on the needs and requirements resulting from the WSL mandate in terms of research, education and services, as well as the overall strategy of the institution and its planning for the period 2021–2024 and beyond. The aim is to ensure IT services with high quality, continuity and security, while also taking into account legal, economic, sustainable and ethical aspects.

New technologies and trends, such as the Internet of Things, Blockchain, Deep Learning and Artificial Intelligence, are already being used in research projects at WSL. To ensure that research can continue to be optimally supported in the future, WSL IT has to remain flexible, respond quickly to requests and new requirements, continue to adapt and further develop, and invest heavily in gaining new knowledge. Due to possibilities for ever simpler exchanges among researchers and institutions, the need for stronger cooperation, and increased flexibility in terms of working spaces and locations (home office), demands on IT services are increasing, as are the related challenges with regard to information security. For example, cloud services require new regulations regarding data security and data protection.

Within the framework of the regular exchanges and cooperation between the ETH Domain institutions in the field of IT, best practices are exchanged, discussed and, where appropriate, harmonized. The

institutions of the ETH Domain plan to develop further projects together or to implement projects with the support of the other institutions. The well-established sharing of expertise and services within the ETH Domain is a tremendous benefit and will be continued and expanded where possible. Examples include the procurement of licences and IT products, exchanges in the field of high-performance computing (HPC), and the joint platform for SAP. A comprehensive, multiyear awareness campaign on information security is planned as a joint project of all ETH Domain institutions.

Overall IT costs needed to develop and maintain the centralized IT infrastructure in the 2021–2024 period will amount to roughly CHF 3.5 to 4 million, similar to values in previous years. In light of the importance of WSL IT and the substantial challenges ahead, a careful prioritization in terms of projects will thus be required.

Long-term access to and scientific benefit from the rich WSL environmental data pool will be ensured through the WSL data portal EnviDat, one of the three WSL programmes launched during the current planning period. EnviDat adheres to the FAIR principles as a research data repository and includes open science support and tools for WSL researchers.

Annex I. List of Acronyms, Names and Abbreviations

This Annex I contains a list of acronyms, names and abbreviations used in the development plan.

Agroscope	Swiss Centre of Excellence for Agricultural Research, affiliated with the Swiss Federal Office for Agriculture
ALPOLE	Alpine and Polar Environment Research Center, a research centre of EPFL in Sion supported by the canton of Valais
ARE	Swiss Federal Office for Spatial Development
Bau3FI	Joint construction and renovation department for Empa, Eawag and WSL
BGB	Joint Eawag-WSL initiative Blue-Green Biodiversity
BSTB	Swiss Federal Civil Protection Crisis Management Board
Burglind	Extratropical storm that caused extensive damage and traffic disruption in large parts of Western Europe in January 2018
C2SM	Center for Climate Systems Modeling, a joint initiative of ETH Zurich, MeteoSwiss, Empa, WSL and Agroscope
CAS	Certificate of Advanced Studies
CCAMM	WSL programme Climate Change Impacts on Alpine Mass Movements
CERC	Climate Change and Extremes Research Center in Davos
ClimAct	Center for Climate, Impact and Action, a joint initiative of EPFL and the University of Lausanne
CHF	Swiss Franc
CRYONET	CryoNet, the core component of the Global Cryosphere Watch Surface Network
Data Science	ETH Domain strategic focus area Big Data and Data Science; initiative for Data Science in Switzerland
DIAGONAL	WSL magazine reporting in English, French and German on WSL's latest research findings and on WSL's work
DNA / eDNA	(Environmental) deoxyribonucleic acid
DNL	Datacenter Nature and Landscape
Eawag	Swiss Federal Institute of Aquatic Science and Technology
EconoMe	Online risk assessment tool, which supports decision-making where protection actions against gravitational processes, including avalanches, debris flows and rockfalls, need to be taken
Editions Paulsen	Publishing house specialized in travel and exploration literature
EGU	European Geoscience Union
Empa	Swiss Federal Institute for Materials Testing and Research
Energy Change Impact	(Research Programme on) Energy Change Impacts, i.e. the effects of the Swiss Energy Strategy 2050 on the environment
ENFIN	European National Forest Inventory Network
EnviDat	(WSL Strategic Initiative) Environmental Data Portal, www.envidat.ch
EPFL	Swiss Federal Institute of Technology Lausanne
ERC	European Research Council
ESA	European Space Agency
ETH	Swiss Federal Institute of Technology
ETH Zurich	Swiss Federal Institute of Technology Zurich
EU	European Union

Evoltree	EVOLution of TREES as drivers of terrestrial biodiversity, a European research group which maintains and provides the scientific community with research facilities, resources and training
EXCLAIM	Extreme scale computing and data platform for cloud-resolving weather and climate modelling, an Open ETH+ 2020 project
FHNW	University of Applied Sciences and Arts Northwestern Switzerland
FAIR principles	A set of guiding principles intended to make data findable, accessible, interoperable and reusable
Fire Niche	Statistical forecasting tool for assessing the risk of forest fires
Flora ZH	Flora of the canton of Zurich; a current and historical overview of the botanical diversity in the canton of Zurich
FOAG	Swiss Federal Office for Agriculture
FOCP	Swiss Federal Office for Civil Protection
FOLAP	Forum Landscape, Alps, Parks of the SCNAT
FOEN	Swiss Federal Office for the Environment (also BAFU – Bundesamt für Umwelt)
GDC	Genetic Diversity Centre at ETH Zurich
GIN	Common information platform for natural hazards
GLP	The Global Land Project, a core project of Future Earth
GLF	Global Landscapes Forum
HPC	High-Performance Computing
HR	Human Resources
IACS	International Association of Cryospheric Sciences
IALE	International Association for Landscape Ecology
ICOS	Integrated Carbon Observation System
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
ISI	Institute for Scientific Information, Web of Science
IT / ICT	Information and Communication Technology
IUCN	International Union for Conservation of Nature
IUFRO	International Union of Forest Research Organizations
LABES	Swiss Landscape Monitoring Program
LAINAT	Steering committee intervention in natural hazards
Lehrplan 21	Common curriculum with harmonized objectives for primary and secondary schools in German-speaking Switzerland
LFI	Swiss National Forest Inventory
Lib4RI	Joint library for the research institutes within the ETH Domain: Eawag, Empa, PSI and WSL
Logbook	WSL's 'Logbook' blog providing reports on researchers' experiences from office, lab and field work
LTER	Long-term Ecosystem Research Network
LWF	(Research Programme on) Long-term Forest Ecosystem Research
MbO	Management by Objectives
MeteoSwiss	Swiss Federal Office for Meteorology and Climatology
Micro-CT	Micro-Computed Tomography
MOSAIC	Multidisciplinary drifting Observatory for the Study of Arctic Climate

MODOEK	WSL Model Ecosystem Open-top Chamber facility
MOOC	Massive Open Online Courses (MOOCs)
MOU	Memorandum of Understanding
NCCS	Swiss National Centre for Climate Services
NFZ	International forest network of research centres located in Nancy, Fribourg and Zurich
NGO	Non-Governmental Organization
PD	Lecturer (Privatdozent)
PERMOS	Swiss Permafrost Monitoring Network
PhD	Doctor of Philosophy
ProSNOW	Research project which aims to build a weather forecast, climate prediction and snow management system specifically tailored to the needs of the ski industry
PSI	Paul Scherrer Institute
RAMMS	(WSL Research Programme on) Rapid Mass Movements; also a software package developed at SLF
SAP	Systems, Applications and Products in data processing
SCION	Scalability, Control, and Isolation on Next-Generation Networks
SCNAT	Swiss Academy of Sciences
SCOPE	Scientific Committee on Problems of the Environment
SDSC	Swiss Data Science Center
SECB	Swiss Expert Committee for Biosafety
SERI	State Secretariat for Education, Research and Innovation
SFA	(ETH) Strategic Focus Area
SFOE	Swiss Federal Office for Energy
SLF	WSL Institute for Snow and Avalanche Research
SME	Small and Medium-sized Enterprise
SnowPack	SNOWPACK; a snowpack and ground surface model
SNSF	Swiss National Science Foundation
SPI	Swiss Polar Institute
SROCC	IPCC Special Report on the Ocean and Cryosphere in a Changing Climate
SWEET	SWiss Energy research for the Energy Transition; a funding programme of the Swiss Federal Office of Energy to accelerate innovations that are crucial for implementing Switzerland's Energy Strategy 2050 and achieving the country's climate policy goals
Swissfire	Forest fire database of Switzerland
SwissForestLab	(WSL Strategic Initiative) Swiss forest research and infrastructure network
SwissFungi	National data centre for fungi
SwissLichens	National data centre for lichens
TPE	Third Pole Environment programme
UNECE-ICPs	United Nations Economic Commission for Europe International Cooperative Programme, e.g. ICP Forest – International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEP	United Nations Environment Programme

Vaia	Extratropical storm which brought severe conditions to Northern Italy and surrounding regions in October/November 2018
waldwissen.net	International information and communication web platform
WAMOS	Sociocultural Forest Monitoring
WhiteRisk	SLF avalanche prevention web portal; provides up-to-date information about the snow and avalanche situation in Switzerland
WMO	World Meteorological Organization
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research
WSL Junior	WSL website targeted at school children, www.wsl-junior.ch

Annex II. WSL Legal Mandate

This Annex II contains German versions of texts defining WSL's legal mandate referred to in Sections 1 and 2 of the development plan. References to the corresponding sources are included. As English is not an official language of the Swiss Confederation, the English formulations and translations in this document are provided for information purposes only and have no legal force.

Section 1.1. Mandate and Foundation for Development Planning

“The ETH Board, which is responsible for the strategic management of the ETH Domain, formulates the ETH Domain's strategy for a performance period, in dialogue with the institutions of the ETH Domain, and supervises its implementation”

Art. 25 Abs. 1 Bst. a,d ETH-Gesetz (4.10.1991) (Stand am 1. Mai 2017):

^a Der ETH-Rat bestimmt die Strategie des ETH-Bereichs im Rahmen der strategischen Ziele des Bundesrates;

^d Der ETH-Rat genehmigt die Entwicklungspläne des ETH-Bereiches und überwacht ihre Verwirklichung.

Art. 12 Abs. 1 Verordnung des ETH-Rates über die Forschungsanstalten des ETH-Bereichs (13.11.2003) (Stand am 20. Januar 2004):

¹ Gestützt auf die Vorgaben des Leistungsauftrags und auf den Zahlungsrahmen schliesst der ETH-Rat mit den ETH und den Forschungsanstalten Zielvereinbarungen für die Dauer von vier Jahren ab. Er berücksichtigt dabei seine strategische Planung und die genehmigten Entwicklungspläne der ETH und der Forschungsanstalten. Kommt keine Einigkeit zustande, so entscheidet der ETH-Rat.

Section 2.2. Background and Mandate

“The purpose of the institutions in the ETH Domain is, as written in Article 2 of the Federal Act on the Federal Institutes of Technology from 4 October 1991”

Art. 2 Zweck, ETH-Gesetz (4.10.1991) (Stand am 1. Mai 2017):

¹ Die ETH und die Forschungsanstalten sollen:

^a Studierende und Fachkräfte auf wissenschaftlichem und technischem Gebiet ausbilden und die permanente Weiterbildung sichern;

^b durch Forschung die wissenschaftlichen Erkenntnisse erweitern;

^c den wissenschaftlichen Nachwuchs fördern;

^d wissenschaftliche und technische Dienstleistungen erbringen;

^e Öffentlichkeitsarbeit leisten;

^f ihre Forschungsergebnisse verwerten.

² Sie berücksichtigen die Bedürfnisse des Landes.

³ Sie erfüllen ihre Aufgabe auf international anerkannten Stand und pflegen die internationale Zusammenarbeit.

⁴ Die Achtung vor der Würde des Menschen, die Verantwortung gegenüber seinen Lebensgrundlagen und der Umwelt sowie die Abschätzung von Technologiefolgen bilden Leitlinien für Lehre und Forschung.

“The autonomy and the duties of the ETH Domain research institutes are, as written in Article 21 of the Federal Act on the Federal Institutes of Technology from 4 October 1991”

Art. 21 Autonomie und Aufgaben, ETH-Gesetz (4.10.1991) (Stand am 1. Januar 2015):

¹ Die Forschungsanstalten sind autonome öffentlich-rechtliche Anstalten des Bundes mit Rechtspersönlichkeit.

² Sie forschen in ihrem Aufgabenbereich und erbringen wissenschaftliche und technische Dienstleistungen.

³ Sie stehen nach ihren Möglichkeiten Hochschulen für Lehre und Forschung zur Verfügung.

“According to Article 3 of the Regulations of the ETH Board concerning the research institutions of the ETH Domain from 13 November 2003, WSL has the following mandate:”

Art. 3 WSL, Verordnung des ETH-Rates über die Forschungsanstalten des ETH-Bereichs (13.11.2003) (Stand am 20. Januar 2004):

¹ Die WSL ist in der nachhaltigen Raumentwicklung, insbesondere der Entwicklung im Berggebiet und im Ballungsraum, in folgenden Fachgebieten tätig:

^a Landschaftsforschung;

^b Waldökologie und Waldmanagement;

^c Naturgefahren und integrales Risikomanagement;

^d Schnee, Eis und Lawinen sowie Permafrost.

² Als Fachstelle erbringt die WSL im Rahmen ihrer Möglichkeiten folgende Dienstleistungen:

^a Sie sichert den Lawinenwarndienst der Schweiz und informiert die Öffentlichkeit über die Lawinengefahr.

^b Sie betreibt die Fachstelle Waldgesundheit Schweiz nach Artikel 30 Absatz 2 der Waldverordnung vom 30. November 1992.

^c Sie sichert die wissenschaftlich-technische Betreuung des forstlichen Pflanzenschutzes nach Artikel 44 der Pflanzenschutzverordnung vom 28. Februar 2001.

Section 2.3. National Tasks

“In addition to the basic mandate, WSL is mandated by federal legislation to provide a range of national services related to the terrestrial environment. It thus provides, to the greatest extent possible, the following services:”

(i) “Running the Swiss National Forest Inventory, the monitoring of Swiss Natural Forest Reserves and the Long-term Forest Ecosystem Research Programme”

Art. 37a Paras. 2 und 3 Waldverordnung vom 30. November 1992 (Stand am 1. Januar 2020):

² Das BAFU erhebt in Zusammenarbeit mit der WSL:

^a im Landesforstinventar die Grundlagendaten zu den Standorten, den Funktionen und zum Zustand des Waldes;

^b die langfristigen Entwicklungsprozesse in den Naturwaldreservaten.

³ Die WSL erhebt im Rahmen ihres Grundauftrags in langfristigen Forschungsprogrammen die Belastung des Waldökosystems.

(ii) “Providing the Avalanche Warning Service for Switzerland and informing the public about avalanche danger”

Art. 9 Para. 1 Bst c Alarmierungs- und Sicherheitsfunkverordnung vom 18. August 2010 (Stand am 1. Januar 2019):

¹ Für die Warnungen vor den nachstehenden Naturgefahren sind als Fachstellen des Bundes zuständig:

^c Lawinengefahren: das Institut für Schnee- und Lawinenforschung (SLF) der Eidgenössischen Forschungsanstalt für Wald, Schnee und Landschaft (WSL);

Art. 3 Para. 2 Bst a, WSL, Verordnung des ETH-Rates über die Forschungsanstalten des ETH-Bereichs (13.11.2003) (Stand am 20. Januar 2004):

² Als Fachstelle erbringt die WSL im Rahmen ihrer Möglichkeiten folgende Dienstleistungen:

^a Sie sichert den Lawinenwarndienst der Schweiz und informiert die Öffentlichkeit über die Lawinengefahr.

(iii) “Running the Swiss Forest Health Service”

Art. 30 Para. 2 Waldverordnung vom 30. November 1992 (Stand am 1. Januar 2020):

Die Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft (WSL) hat folgende Aufgaben:

^a sie organisiert zusammen mit den kantonalen Forstdiensten die Erhebung von Daten, die für den Waldschutz von Bedeutung sind;

^b sie informiert über das Auftreten von Organismen und anderen Einflüssen, die den Wald gefährden können;

^c sie berät in Waldschutzfragen die eidgenössischen und kantonalen Fachstellen.

(iv) “Providing scientific and technical support for forest health protection”

Art. 103 Pflanzengesundheitsverordnung vom 31. Oktober 2018 (Stand am 1. Januar 2020):

Die Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft ist für die wissenschaftlich-technischen Belange der Pflanzengesundheit im forstlichen Bereich zuständig.

Art. 3 Para. 2 Bst c, WSL, Verordnung des ETH-Rates über die Forschungsanstalten des ETH-Bereichs (13.11.2003) (Stand am 20. Januar 2004):

² Als Fachstelle erbringt die WSL im Rahmen ihrer Möglichkeiten folgende Dienstleistungen:

^c Sie sichert die wissenschaftlich-technische Betreuung des forstlichen Pflanzenschutzes nach Artikel 44 der Pflanzenschutzverordnung vom 28. Februar 2001.

Art. 72. Para. 2 Pflanzenschutzmittelverordnung vom 12. Mai 2010 (Stand am 1. Januar 2020):

² Das BLW mit seinen eidgenössischen landwirtschaftlichen Forschungsanstalten und der Eidgenössischen Forschungsanstalt für Wald, Schnee und Landschaft (WSL) stellt sicher, dass ein Pflanzenschutzmittel:

^a für die vorgesehene Verwendung hinreichend geeignet ist und bei vorschriftsgemäsem Gebrauch keine unannehmbaren Nebenwirkungen auf Nutzpflanzen und Erntegüter zur Folge hat;

^b bei vorschriftsgemäsem Umgang keine unannehmbaren Nebenwirkungen auf Mensch, Tier und Umwelt hat.