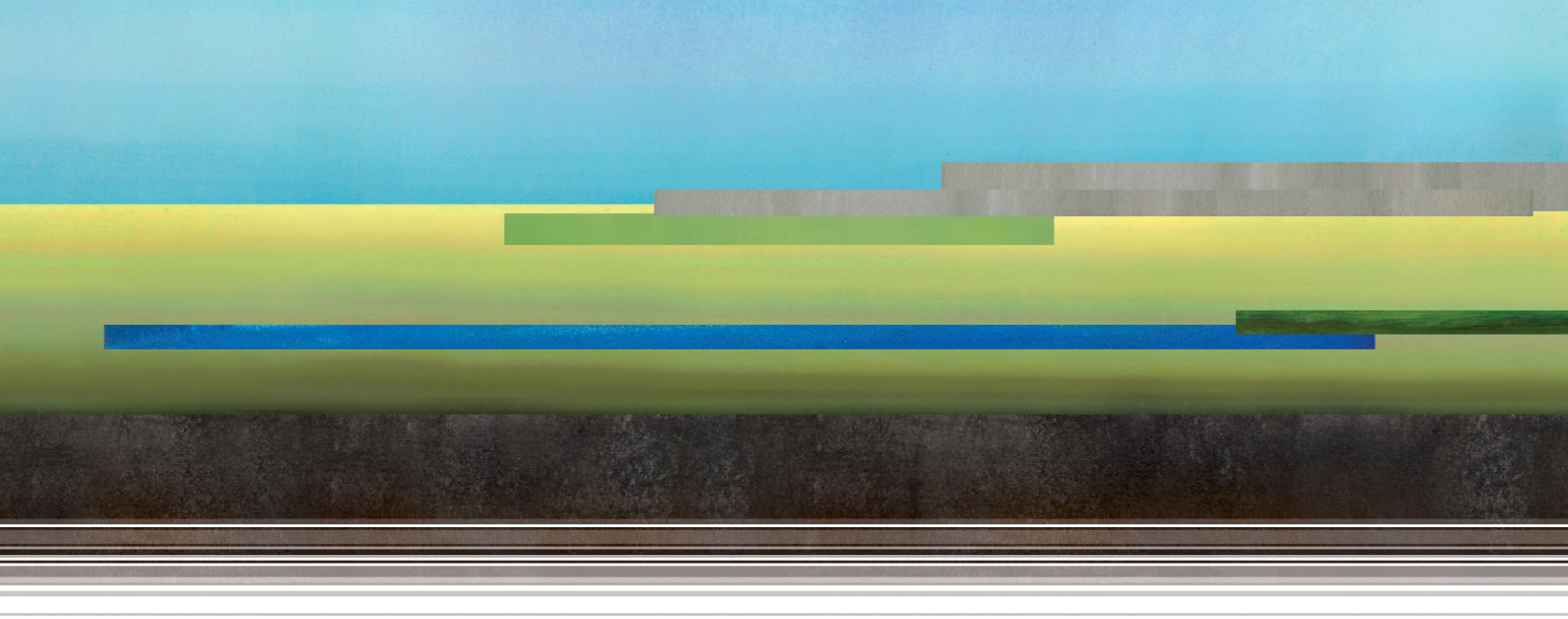


Portrait of the National Research Programme, NRP 68

Soil as a resource

FNSNF
Swiss National Science Foundation

Contents

www.nrp68.ch

What is a national research programme (NRP)?
The National Research Programmes (NRPs) generate scientific knowledge aimed at solving urgent problems of national significance. They are approved by the Federal Council, last from four to five years and have a budget of up to 20 million Francs. NRPs are problem-oriented and are inter and transdisciplinary. The individual research projects and groups are coordinated in order to work towards a defined overall goal.

Soil as a resource: the ill-known dimension

The soil is a thin and fragile layer that covers large parts of the continents. The soil is of course therefore a limited resource. In densely populated Switzerland, and especially in the central areas of the country, it is scarce. For decades, however, a square metre of arable land has been lost every second, mostly for housing and infrastructure developments, but also as the result of forest spread.

In recent times, intense debates have taken place once more about how much land should be available for housing and leisure needs. During discussions on high rental costs, urban sprawl, compaction and the construction of second homes, the question that usually arises is what surface area should and may be used, and for which purpose. The soil is taken to be a two-dimensional object to which an economic value is attributed: the greater the extent to which it can be exploited, the higher the value.

Little attention is given to the wide range of services that the soil can provide. The soil provides these services as an underground ecosystem – as a three-dimensional habitat. These services are for us as human beings of extraordinary importance. The most important role of the soil is that of a production factor for agriculture and forestry. Indeed, intact, fertile soils are the basis for plant

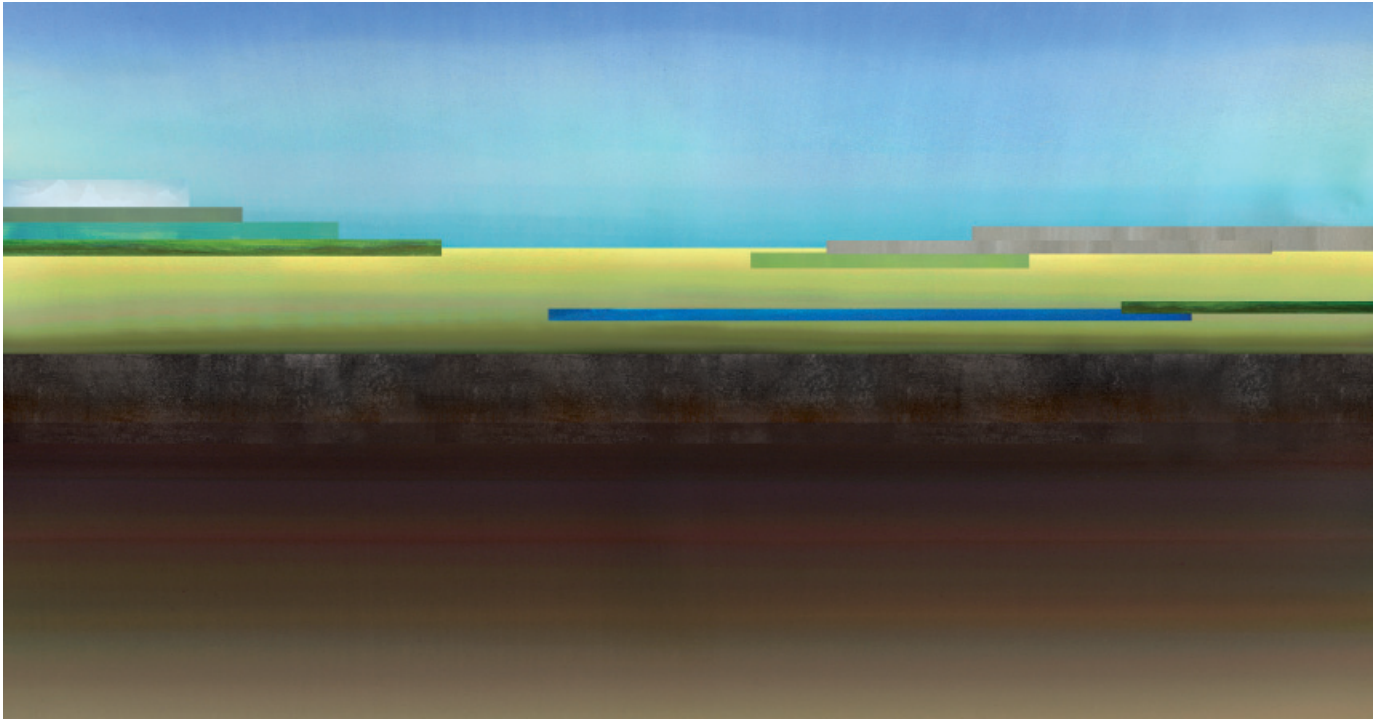
Prof. Josef Zeyer
President of the NRP 68
Steering Committee

growth and hence for feeding people and animals. The soil is, however, also a diverse habitat and therefore of utmost importance for maintaining biodiversity. Only a small part of the living organisms in the soil can, however, be directly observed. For the most part, these are small organisms such as bacteria and fungi, which can only be identified using special technical methods. It is, however, these small organisms that help the soil to provide its important functions. They guarantee an important part of the cycling of matter, which ensures that the plants can thrive. They also ensure that the soil has a crumbly and porous structure. Thanks to them, the soil can absorb and hold water like a sponge. In so doing, it regulates water drainage and reduces the risk of flooding. Through carbon sequestration, the soil also plays a central role in the climate system.

These varied functions of the soil are not only underestimated, too little is understood about the these functions, quantitatively speaking. We also know too little about the interactions between the soil, land use and the atmosphere, and between the individual structural elements of the soil and the various soil functions. First and foremost, however, there is also a lack of methods and instruments to render soil functions comprehensible – when dealing for example with planning issues – and to make these functions an important criterion in the land market. These shortcomings hinder sustainable management of soil as a resource. The National Research Programme "Soil as a Resource" (NRP 68), through its research work, wishes to help to rectify these shortcomings.

The results of NRP 68 should also help to make the diverse functions of the soil visible and tangible for the environment and for society. This should also raise awareness of those involved in politics, public authorities and business about the scarcity of soil as a resource. The aim of NRP 68 is to develop concepts to enable sustainable resource management.

The members of the Steering Committee are pleased to be able to carry out this work with the researchers involved in this programme, and to be able to contribute to the future viability of Switzerland.



Soil for the future

How can the soil be used or if necessary protected so that its functions can be maintained for the future or even just be promoted? This is a central issue that must be tackled to ensure sustainable and efficient management of the soil as a resource.

Sustainable management of the soil as a resource must deal with many challenges and stress factors:

First, there are various demands placed on the land, which mainly bring about a total loss of the soil. Population growth and an increasing need for individual living area (number of square metres per inhabitant) are bringing about the constant, and in many places uncoordinated, spread of housing (urban sprawl). Leisure pursuits too are constantly requiring greater areas of land, be it for tourism or, for example, for sport and entertainment facilities. Finally, society also continually needs more space for infrastructure and logistics, such as roads, rail networks, mains and cabling. Owing to the energy transition, there is increasing pressure to use land for the production, supply and transportation of energy, for instance as a location for wind and solar energy plants or for the cultivation of biofuels.

Carelessly or incorrectly treating the soil harms soil quality.

Even leaving housing out of the equation, land use is changing at a great pace. Agriculture is intensifying its land use in the valley regions and is reducing it in other places. In the Alpine and pre-Alpine region, forest is increasingly spreading to former agricultural land. More and more is being used for leisure pursuits, to build golf courses for example, leading to the loss of arable land.

Carelessly or incorrectly treating the soil – such as on building sites or in agriculture – harms soil quality. The soil becomes damaged and can no longer fulfil its functions. The excessive stress placed on the soil destroys the soil structure, leads to compaction and thereby to lasting or even irreversible harm. Contaminants enter the soil via the air, and in fertilisers and pesti-

cides. Some of them are retained by the soil, and their concentrations slowly rise.

As a carbon buffer the soil plays an important role in connection with climate change.

Thanks to its ability to act as a buffer, and to absorb substances as well as to release them, the soil plays an important role in connection with climate change. As the temperature increases water will tend to evaporate, and the soils will become drier. As an important carbon store, the soil is a significant part of the carbon cycle, a key factor of the greenhouse effect.

In light of this challenge maintaining and increasing the soil's effectiveness in the future constitutes a very tough task.

It presupposes that knowledge about the soil and its functions is compiled from different fields, and has an effect on the actions of those involved in politics, public authorities, business and society.

NRP 68: Understanding the services of the soil and making them visible

The approach to soil research has been highly discipline-based until now. NRP 68 would like to change this attitude, and at the same time specifically connect soil use with ecosystem services provided by the soil. For this, there is a financial framework of 13 million Swiss francs available. During the first stage, NRP 68 unifies 19 research projects.

Both at the national and international level, soil research is often focused on individual disciplines or on the understanding of selected processes. NRP 68 is departing from this stance, and is following the approach of linking soil use with the ecosystem services provided by the soil. There are, however, two conflicting views on this: the traditional soil sciences – physics, chemistry and biology – demand that the soil be perceived in a three-dimensional manner (soil as volume, in cubic metres). For questions of land use, however, a two-dimensional view predominates (soil as a surface area, in square metres). This mainly concerns disciplines from the political sciences and the field of law.

NRP 68 links soil use with the ecosystem services provided by the soil.

At the heart of NRP 68, stands the increasingly scarce resource of soil, with its large number of functions. NRP 68 aims to contribute to a better understanding of the processes in the soil at macro- and microscopic level, and to understand and evaluate soil services more precisely, so that soil as a resource in Switzerland can be managed sustainably and efficiently.

The issues looked at in the programme are divided into three modules, while the research projects will be handled on a cross-module basis. This gives rise to key aspects, on which various research projects can work together intensively, already during the early research phase, and closely coordinate their data gathering methods.

Research Module 1:
Knowledge of the soil system

In this module, attention will be paid to the processes in the soil itself and to the interactions between the soil and the atmosphere, but also to the relationship between land use in agriculture and forestry, or housing development and soil functions. The question is then raised as to how biodiversity in the soil affects the above-ground ecosystem and the soil functions, and as to which agricultural methods support these important soil functions. Various aspects are connected to climate change: How does climate change affect the various soil functions and where are the sources and sinks located for greenhouse gases? Are there connections between climate change and erosion?

Research module 2:
Tools to assess the soil as a resource

This module is dedicated to the development of instruments with which soil qualities and services can be understood and measured. Which indicators are suitable, for example, to understand soil fertility, soil quality and changes in soil functions? Or how can questions about soil quality be incorporated into planning processes? Problems are also raised when creating cartographic representations (mapping). It is then of interest how soil properties, as well as soil quality and functions, can be clearly mapped, spatially. With regard to housing development, the question is posed as to how current developments are to be analysed and how the effects of different developments on soil structures and soil functions are to be assessed.

Research module 3:
Concepts and strategies on sustainable use of the soil as a resource

This module deals with the tools for sustainable resource management. The fiscal incentives and economic instruments which are suitable for promoting careful handling of the soil as a resource should be demonstrated, while ensuring that the ecological value of the soil is taken into consideration. There is also a demand for solutions that improve the interaction between land-use planning, energy and resource policy and qualitative soil protection. Which strategies help target-conflicts between biodiversity, fertility, land-use and productivity to be recognised and to be solved sensibly? Are there methods that help to boost soil protection, to reduce the pressure of housing

development and to condense housing in an intelligent and socially responsible manner? Legislation should also be checked to determine whether it is able to regulate the sustainable use of the soil and the land, or whether there are any loopholes. Finally, the global view is of interest, such as the question of what the effects are of exploiting fertile soils abroad.

An overview of NRP 68 projects

More information on research projects can be found at www.nrp68.ch

Project “Land Grabbing”
Land Grabbing with Swiss involvement
Dr. Stephan Rist, University of Berne

Key aspect 1:
Carbon and Soil Organic Matter (SOM)

Project “Vulnerability indicators”
Indicators for soil carbon vulnerability
Prof. Timothy Eglinton, ETH Zurich

Project “Forest soils”
Carbon reserves in Swiss forest soils
Dr. Frank Hagedorn, Swiss Federal Institute for Forest, Snow and Landscape (WSL)

Project “Carbon dynamics”
The effect of climate and land use change on soil carbon in Swiss soils.
Dr. Samuel Abiven, University of Zurich

Project “Peatlands”
Management of organic soils
Dr. Jens Leifeld, Agroscope Reckenholz-Tänikon Research Station (ART), Reckenholz

Key aspect 2:
Soil Biology

Project “Mycorrhiza”
Restoration of soil functions with the help of arbuscular mycorrhiza
Prof. Marcel van der Heijden, Agroscope Reckenholz-Tänikon Research Station (ART), Zurich

Project “Nematodes”
Use of nematodes in the fight against harmful soil insects
Prof. Ted Turlings, University of Neuchâtel

Project “Soil bacteria”
Healthy soils thanks to soil bacteria
Dr. Monika Maurhofer, ETH Zurich

Project “Antibiotic resistance”
The role of land use in antibiotic resistance
Dr. Brion Duffy, Zurich University of Applied Sciences (ZHAW), Wädenswil

Key aspect 3:
Farming

Project “Nitrous oxide”
Effects of land use on soil micro-organisms that form and decompose nitrous oxide
Dr. Andreas Gattinger, Research Institute for biological agriculture, Frick

Project “Carbon input”
Soil carbon input through crop plants
Dr. Jochen Mayer, Agroscope Reckenholz-Tänikon Research Station ART, Zurich

Project “Cover crops”
Protection of the environment with cover crops and conservation agriculture
Dr. Bernhard Streit, School of Agriculture, Forest and Food Sciences (HAFL), Zollikofen

Project “Soil compaction”
Regeneration of compacted soils
Dr. Thomas Keller, Agroscope Reckenholz-Tänikon Research Station (ART), Zurich

Key aspect 4:
Geographic Information and Cartography

Project “Burden balancing”
Sustainable soil management through balancing of economic and ecological gains and losses
Prof. Stéphane Nahrath, Institut Universitaire Kurt Bösch, Sion

Project “Urban sprawl”
Controlling urban sprawl – limiting soil consumption
Prof. Felix Kienast, Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf

Project “Soil maps”
Predictive mapping of soil properties for the evaluation of soil functions at regional scale
Dr. Andreas Papritz, ETH Zurich

Project “Early warning system”
Regional soil monitoring tool for sustainable element cycles on agricultural soils
Dr. Armin Keller, Agroscope Reckenholz-Tänikon Research Station (ART), Zurich

Project “Decision-making platform”
Decision-making platform for sustainable soil use
Prof. Adrienne Grêt-Regamey, ETH Zurich

Project “Soil stability”
Soil stability and natural hazards: from knowledge to action
Dr. Frank Graf, WSL-Institute for Snow and Avalanche Research, SLF, Davos

Project “Land Grabbing”
Land Grabbing with Swiss involvement
Throughout the world, agricultural land is being bought up or leased by countries with a lack of arable land or by international investment funds – to date, the figure comes to around 83 million hectares. Africa is the continent that is most affected by the phenomenon of land grabbing – then to a lesser extent, many Asian countries, Russia, Central and South America. Stephan Rist and his team are examining the effects of land grabbing by Switzerland.

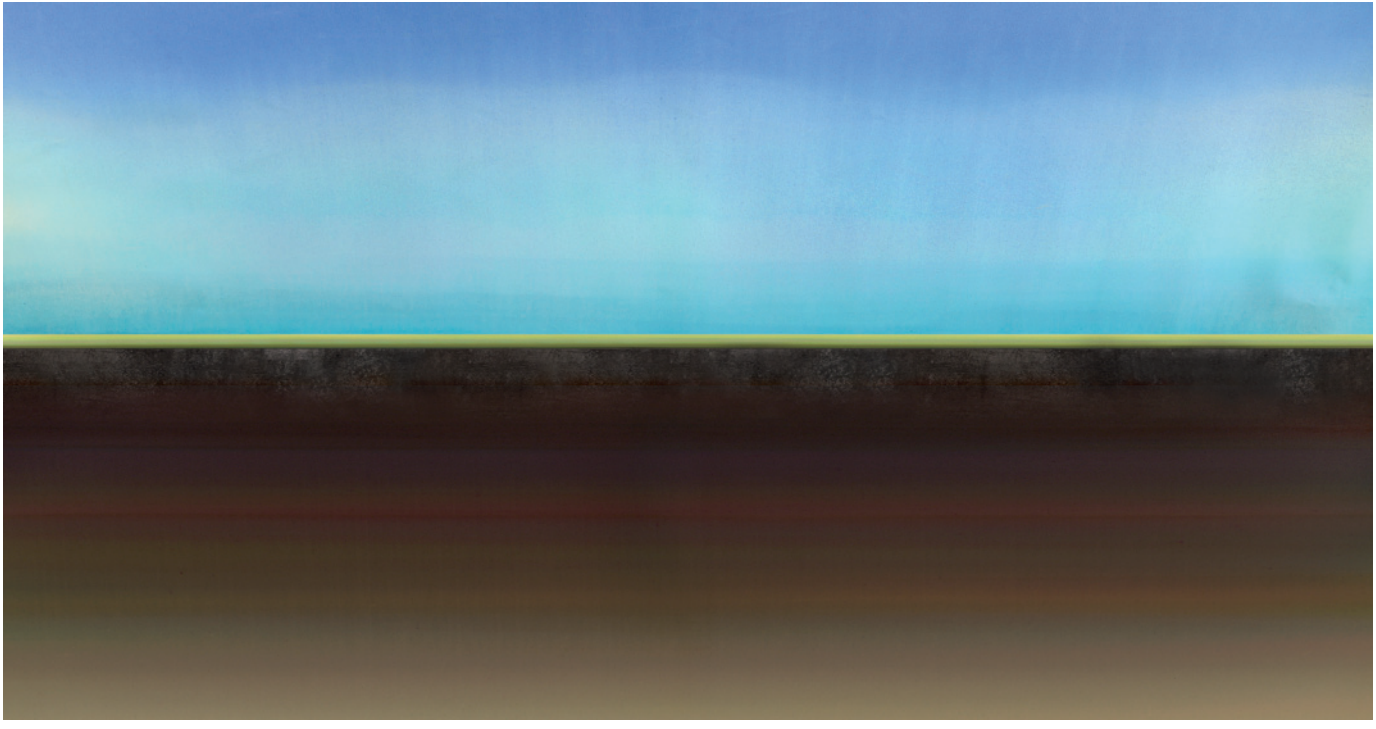
Key aspect 1: Carbon and Soil Organic Matter (SOM)

The carbon cycle is the key factor for the greenhouse effect. The soil, as a significant carbon store, plays a decisive role in this. At the same time, carbon-based soil organic matter plays a key role for many soil functions.

Project “Vulnerability indicators”
Indicators for soil carbon vulnerability
Not enough is yet known about the effects perturbation has on carbon in the soil. Timothy Eglinton and his team are examining how carbon in various Swiss soils reacts to climate change and changes in land management. Based on this information, we can make forecasts about how carbon will behave faced with climate and land use change.

Project “Forest soils”
Carbon reserves in Swiss forest soils
Frank Hagedorn and his team are investigating to what extent climatic conditions, historical land use, forest management and physico-chemical soil properties determine carbon storage in Swiss forest soils. The soil database of the Swiss Federal Institute for Forest, Snow and Landscape (WSL) serves as the basis.

Project “Carbon dynamics”
The effect of climate and land use change on soil carbon in Swiss soils.
How long carbon remains in the soil is a key factor, but until now this has been little understood. Samuel Abiven and his team would like to raise the understanding of the dynamics of soil carbon. They are particularly concerned with the reaction of the soil



organic matter to climate change and to changes in land use.

Project “Peatlands”
Management of organic soils
Soils from former peatlands are dwindling very quickly in certain farming systems. Jens Leifeld and his team are investigating how previous use has affected these peatlands, and which alternative uses are available to slow down peat loss. They are also analysing the use history and investigating the vulnerability of former peatlands. New policy instruments should show how alternative uses can be promoted.

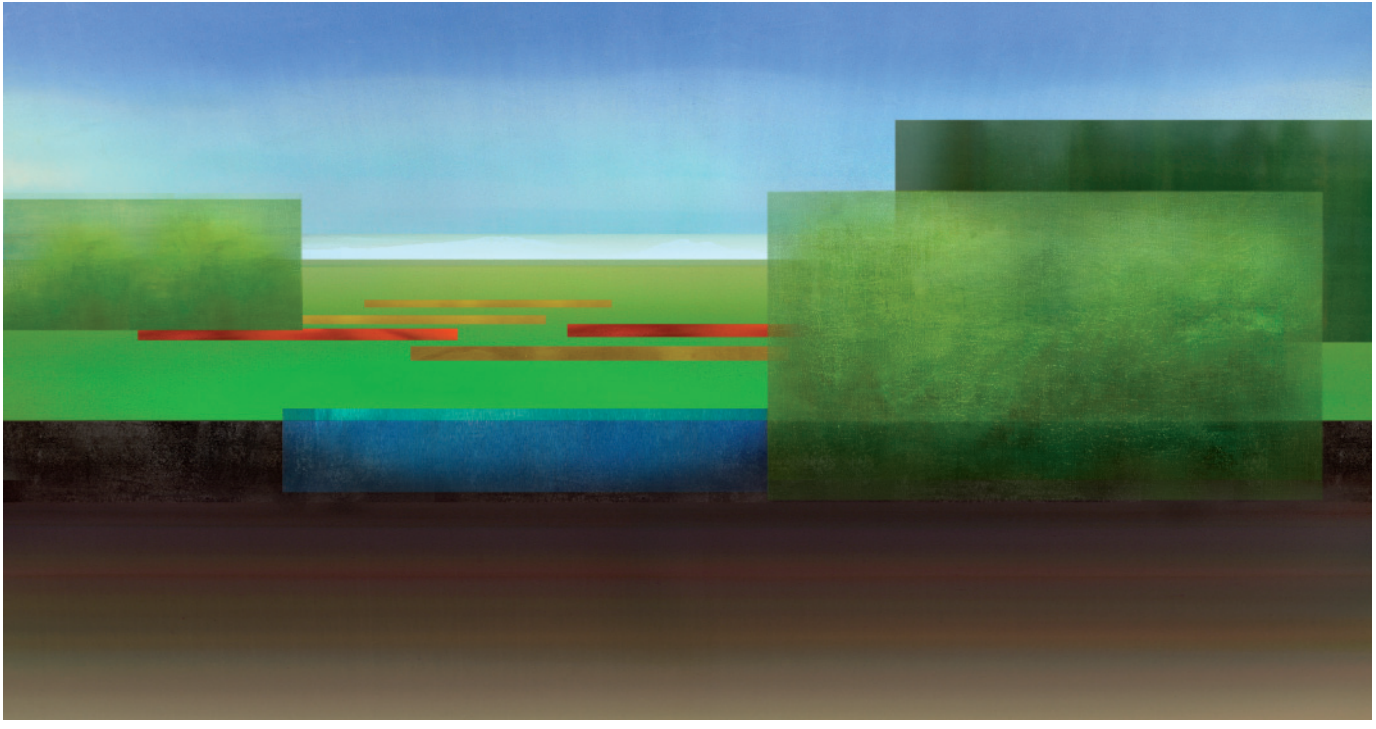
Key aspect 2: Soil Biology

The soil is the habitat for a wide range of soil organisms, which are crucial for various soil functions, in particular for soil fertility.

Project “Mycorrhiza”
Restoration of soil functions with the help of arbuscular mycorrhiza
Arbuscular mycorrhiza fungi, a common group of soil fungus, form symbiotic relationships with most plants. They play a crucial role for various ecosystem services of the soil such as improving plant nutrition. Marcel van der Heijden and his team are examining whether it is possible to improve the services of agro-ecosystems through inoculation with these beneficial soil fungi.

Project “Nematodes”
Use of nematodes in the fight against harmful soil insects
The pesticide potential of micro-organisms, of which there are many kinds that occur in the soil, has not been exhausted. Ted Turlings and his team are studying so-called entomopathogenic nematodes (EPN), tiny roundworms that can kill off insects living the soil. The team aims to record the frequency and the types of nematodes in various habitats and to check whether they are suitable for use as biological pest control.

Project “Soil bacteria”
Healthy soils thanks to soil bacteria
Bacteria that occur naturally in the soil can colonise plant roots and protect the plants from harmful fungi. Monika Maurhofer and Christoph Keel



are looking for ways to promote the health of Swiss agricultural soils with the help of naturally occurring soil bacteria, and to improve their health through targeted use of these bacteria.

Project “Antibiotic resistance”
The role of land use in antibiotic resistance
Antibiotic resistant bacteria are increasingly placing the healthcare system before huge challenges. Soils, especially as a consequence of applying liquid manure, represent a possible source for the development of resistance. The actual risk is, however, not yet well known. Brion Duffy and his team are therefore testing soils for genetic traces of antibiotic resistance and are analysing the effect of land use on resistance dynamics.

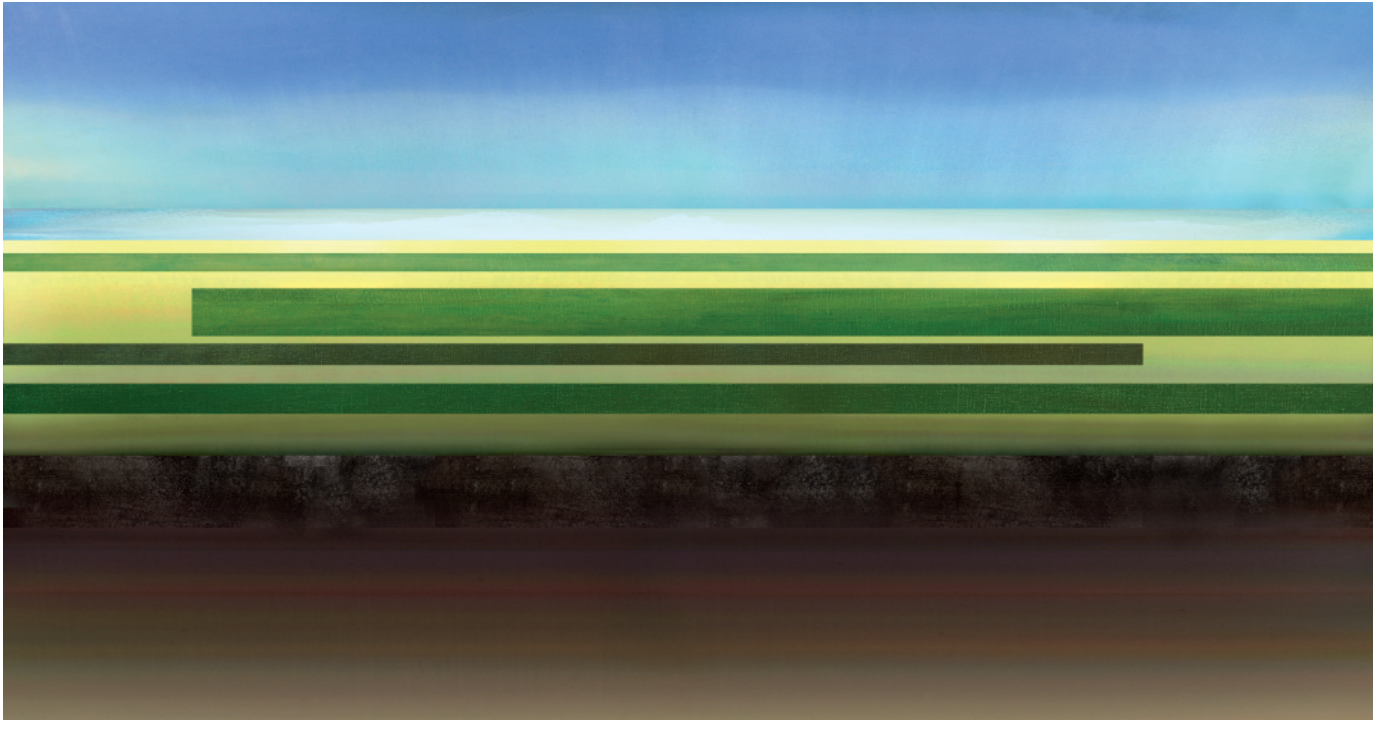
Key aspect 3: Farming

The type of agricultural management affects soil quality in different ways. It can support soil functions, but it can also diminish them.

Project “Nitrous oxide”
Effects of land use on soil micro-organisms that form and decompose nitrous oxide
Agriculturally exploited soils represent an important source of nitrous oxide that has a strong effect on the climate. Andreas Gattinger and his team are examining the role played by living micro-organisms in the soil in the production and decomposition of nitrous oxide in the soil, and how agricultural practices affect these micro-organisms.

Project “Carbon input”
Soil carbon input through crop plants
The roots of arable crops are vitally important for the formation of soil organic matter in agriculture. Jochen Mayer and his team are investigating how much carbon is translocated to the soil through the roots of important Swiss field crops. At the same time, the effect of various farming systems is monitored.

Project “Cover crops”
Protection of the environment with cover crops and conservation agriculture
Conservation agriculture increases farming productivity and contributes to protecting fields at the same time. Cover crops cover the ground between two main crop periods, promote soil fertility, improve availability of plant nutrients and suppress weeds.



The team of Bernhard Streit and Raphaël Charles are examining the demands that individual cover crops place on the habitat, and the benefits that they provide.

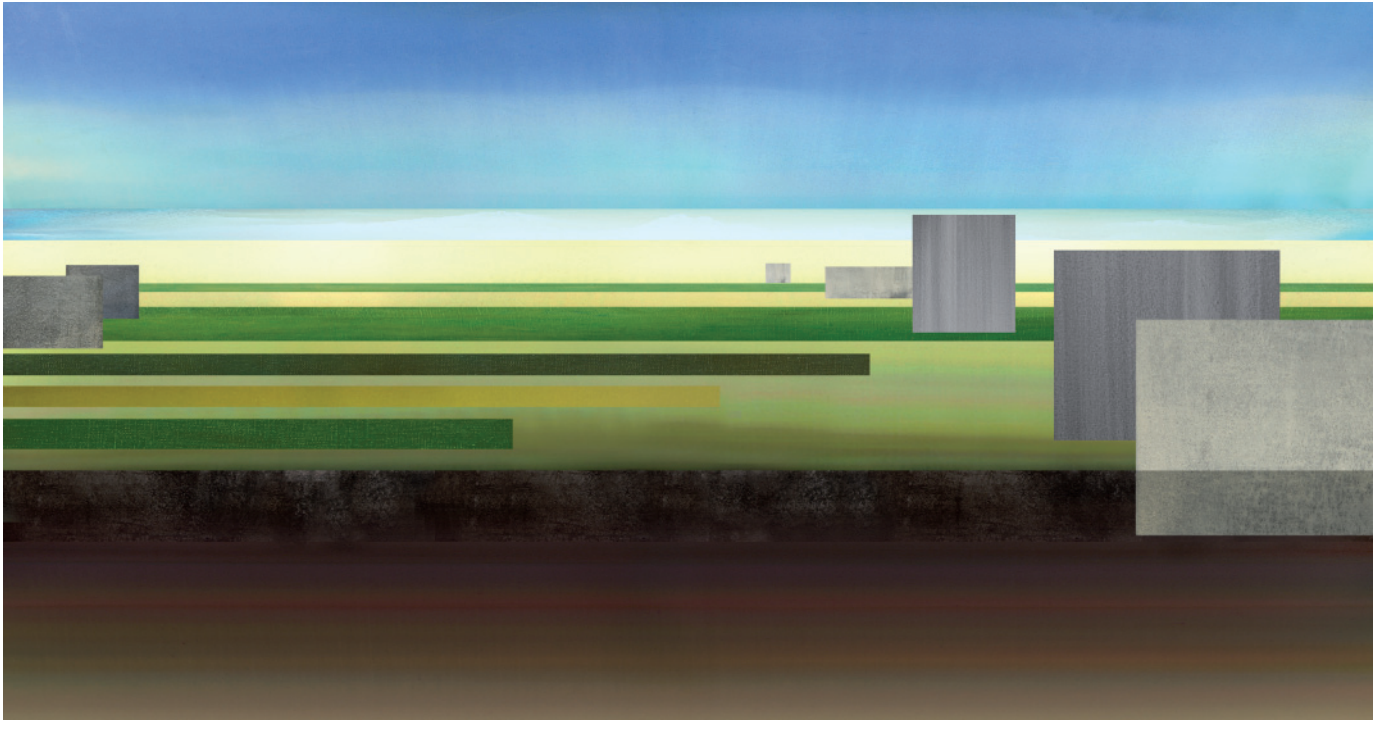
Project "Soil compaction"
Regeneration of compacted soils
Stresses applied by agricultural machinery can lead to soil compaction, thereby reducing soil pore space, modifying the soil structure and impairing important soil functions. The team of Thomas Keller is tackling the question of how quickly the soil structure recovers from compaction, and which natural mechanisms control soil structure recovery.

Key aspect 4: Geographic Information and Cartography

Available information on soil aspects is not spatially inclusive and comprehensive, but such information is needed for sustainable land management. Required are not only data on land use, but also on soil functions and soil quality.

Project "Burden balancing"
Sustainable soil management through balancing of economic and ecological gains and losses
The lack of a balance between gains and losses makes it difficult to reach sensible solutions both for development planning and for soil protection. Stéphane Nahrath and his team are analysing the mechanisms that lead to economic and ecological gains and losses. The team will be testing various burden balancing instruments for effectiveness, and will compare and test them in three case study areas.

Project "Urban sprawl"
Controlling urban sprawl – limiting soil consumption
Building on the urban sprawl data going back to 1885, the team of Felix Kienast is examining which political, planning and socio-economic factors contribute to urban sprawl and to unbridled soil consumption. The team is developing forecast models and aims to estimate, using various scenarios, the effect of new planning instruments and of financial incentive systems, as well as future soil consumption. Based on that, practical proposals to reduce urban sprawl should result.



Project “Soil maps”
Predictive mapping of soil properties for the evaluation of soil functions at regional scale
Detailed spatial soil information is required to sustainably manage the soil resource and to take its many services to society into account in spatial planning. This information is only available for a small part of Switzerland. The team of Andreas Papritz uses methods of digital soil mapping to efficiently generate spatially high-resolution and contiguous soil information and to establish an evaluation system for assessing soil functions for Swiss soils.

Project “Early warning system”
Regional soil monitoring tool for sustainable element cycles on agricultural soils
The agricultural use of soils affects their element cycles and thereby the important functions of the soil. Alongside fertilisers, auxiliary substances and the desired fertilisers, contaminants are also applied, which accumulate in the long-term in soil. Armin Keller and his Team are developing an integrated monitoring framework for preventive soil protection. The tool should help to identify non-sustainable developments in the soils of a region early on and to plan and check the effectiveness of the preventative measures taken.

Project “Decision-making platform”
Decision-making platform for sustainable soil use
A sustainable use of our soil resources requires balancing uses against the capacity of soil to provide the required services over space and time in the future. Adrienne Grêt-Regamey and her team are developing a 3D virtual platform with which the various parties can develop strategies together to achieve sustainable soil use. The effectiveness of new instruments is tested in the platform, thus enabling recommendations for sustainable soil use to be formulated directly as a result.

Project “Soil stability”
Soil stability and natural hazards:
from knowledge to action
Erosion and landslides repeatedly cause damage in Switzerland. Frank Graf and

his team are investigating the effect of plants and fungi on soil stability. They are relying among other things on a database in which over 700 landslides have been documented in detail. Soil-mechanical experiments in the field and in the laboratory will provide the necessary additional data. Based on the results, the team will develop indicators that highlight threats of erosion and landslides.

Raising awareness of the value of the soil

A key for sustainable management of soil as a resource lies in knowledge transfer. One of the central concerns of the steering committee is therefore to promote the transfer of knowledge to the relevant stakeholders from politics, business and society, early on. The research teams maintain contacts with their partners. At programme level, networking and dialogue with important stakeholders occupy a key position.

The soil plays a central role in numerous aspects of politics, business and society. NRP 68 aims to raise awareness among the interested parties that the diverse range of functions of the soil can be diminished, maintained or promoted, depending on how it is treated.

Creating a general understanding of the soil

Those dealing with questions relating to the soil mostly work within a specific area, and there is often a lack of discussion on relevant issues. NRP 68 offers an opportunity to connect these various areas and with the help of knowledge obtained from NRP 68 to develop a joint understanding of sustainable soil management. NRP 68 is also seeking to make contact with all those circles that have been tackling soil issues until now. They should be informed of the results of the programme early on and be able to become involved in the activities in a fruitful way.

Making soil comprehensible

Naturally, the world of the soil is hard to see to the naked eye. Important aspects for soil functions such as soil diversity and soil structure are difficult to understand or bring alive for the lay population. This is one of the reasons why soil as a resource is not very present in the general population's consciousness. NRP 68 would therefore like to help to increase awareness of the soil and its functions – using both instruments and methods that develop the projects, but also by way of knowledge transfer, which should demonstrate the services of the soil in the form of images and illustrations.

Programme schedule and organisation

The research of NRP 68 is to last until mid-2018 and is to be divided into two phases of research, lasting three and then two years. During the second phase, research projects with a high potential will be intensified and syntheses will be drawn up. The concluding reports are to be expected by 2018.

2013–2015	**1st Research phase**
January 2013	start of the research projects
June 2013	Kick-off meeting
End of 2013	second call (optional)
Spring 2016	Final reports of the three-year research projects
2016–2017	**2nd Research phase**
2018	**Closing event**

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The key part of its activity entails scientific assessment of research projects. Annually, it provides 700 million Swiss francs of funding to support almost 3,000 projects in which 7,000 researchers are involved.

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NRP 68 in brief

The National Research Programme "Sustainable use of soil as a resource" (NRP 68) is working on the principles for political decision-making processes that sensibly take into account both the ecological and the economic functions of the soil and enable sustainable use of soil as a resource in Switzerland. The programme has a financial framework of 13 million Swiss francs and will last until mid-2018. During the first phase, 19 research teams will be involved.

The aims of NRP 68

The approach to soil research has been highly discipline-based until now. NRP 68 would like to change this attitude, and at the same time specifically connect soil use with ecosystem services provided by the soil.

The researchers of NRP 68 should also:

- improve knowledge about soil systems;
- develop instruments to assess the soil as a resource;
- produce strategies for sustainable land use.

NRP 68 aims to contribute to greater awareness of the soil and its functions, and, using the information obtained, help to develop a common understanding of sustainable soil management.