Schweizerische Eidgenossenschaft
Confédération suisse
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Confederaziun svizra

National Centre for Climate Services NCCS

Swiss Federal Institute for Forest, Snow and Landscape Research WSL

Climate change threatens important ecosystem services provided by Swiss forests, such as timber production, protection against natural hazards, and native biodiversity. This poses major challenges for forestry planning. On behalf of the National Centre for Climate Services (NCCS), ETH Zurich and WSL developed the FORTE and ForClim apps, which show the impact of climate change on various forest services under different climate scenarios. The apps' functionality and sample results are presented below.

THE IMPACT OF CLIMATE CHANGE ON THE ECOSYSTEM SERVICES OF SWISS FORESTS

Due to rising temperatures and increasing drought, certain tree species will no longer be suitable for their current locations in the future. With the ForClim and FORTE apps, you can check how severely the different areas and regions of Switzerland are affected.

Drought, storms, and pest infestations are increasing as a result of climate change and fundamentally altering the ecological conditions for forests in Switzerland. This jeopardizes key ecosystem services such as timber production, protection against natural hazards, and the provision of habitat for native biodiversity. Empirical knowledge and traditional planning tools such as yield tables are indispensable, but they reach their limits in forestry practice when it comes to making decisions for the coming decades regarding sustainable tree species or the development of timber stocks.

Two complementary apps support decision-making:

The **ForClim (Forests in a Changing Climate) app** simulates the future development of forest stands, enabling more informed planning of silvicultural measures to complement the existing Tree-App.

The **FORTE (Forest Tree Explorer) app** provides a map-based overview of changes in the multifunctionality of forests and the ecosystem services derived from them for all of Switzerland.

The apps are aimed at public sector specialists, foresters, companies, planning and consulting firms, researchers, and interested members of the public.

CONSEQUENCES OF CLIMATE CHANGE

- **The availability of the most important native tree species for forestry will decline under future climatic conditions, as these species will no longer be suitable in various locations where they grow today in the future due to rising temperatures and increasing drought.**
- **Without the targeted promotion and planting of climate adapted tree species, the stability and productivity of forests may decline.**
- **Climate change, extreme weather events, and other natural disturbances such as pests can increase tree mortality. Mixed forests are often more resilient than species-poor forests, as existing resources such as water and nutrients are better utilized and competition is avoided under unfavourable conditions.**

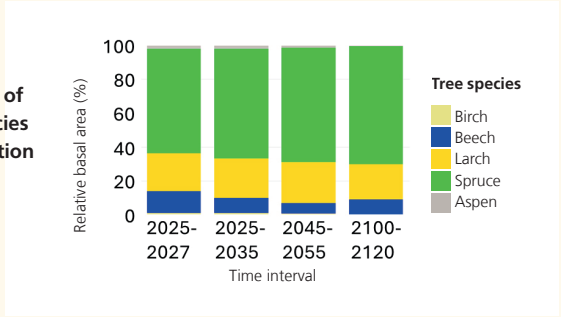
INDICATORS AVAILABLE IN THE ForClim APP

Future tree species composition

Indicator for climate fitness

The app simulates how the species composition of a forest will change over time under different climate scenarios. This information enables foresters to plan climate-resilient forests and promote climate adapted tree species. It allows them to understand which tree species composition will be appropriate in 50 years and how quickly different tree species will lose their competitive advantage at a given location.

Example of tree species composition
RCP 8.5*

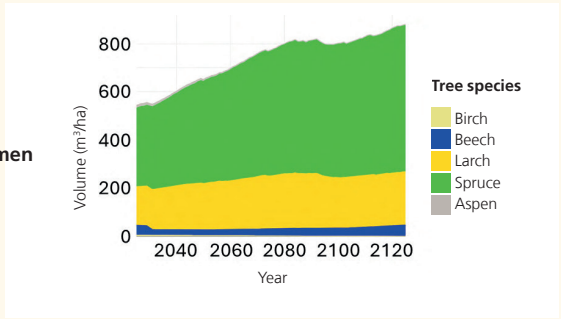


Stand development

Indicator for growth and timber use

The app provides results on the future development of biomass, timber stocks, and growth. With the help of dynamic time series graphics, foresters can strategically plan harvesting times: the app shows whether it makes sense to thin the forest and promote the regeneration of tree species.

Example of stand developmen
RCP 8.5*

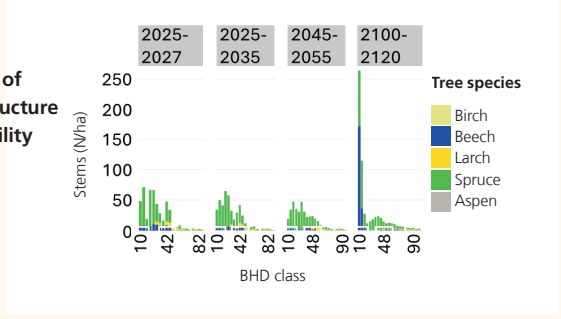


Stand structure and stability

Indicator of resilience

The app indicates the future diameter distribution of the trees and the development of the ratio of tree height to trunk diameter (h/d, slenderness ratio). These variables are important indicators of the stability of a stand. This aspect has a higher priority than pure timber stock, especially in mountain forests, where the protective function is paramount.

Example of stand structure and stability
RCP 8.5*



*Climate scenario without global climate protection
Absolute change in the period 2045-2074 compared to the reference period 1981-2010

Scientific basis of the ForClim app

The methodology was developed in collaboration with foresters. It is based on a neural network (NN) that was trained using practical input data. From a few easily collected parameters (e.g., number of stems, main tree species, development stages), it generates a high-resolution stem distribution for the entire stand. In a second, scientifically validated step, this overall distribution is divided among the individual tree species using the tree species proportions specified by the user. This detailed distribution is then converted into a tree list, which serves as the starting point for simulating future forest development.

The app is still based on the older generation of climate scenarios (CH2018 climate scenarios). The new climate scenarios CH2025 climate scenarios vare now available. However, the main qualitative statements in both climate scenarios remain unchanged.

Technical report
CH2018 climate scenarios for Switzerland
Modeling with the dynamic forest model ForClim
Hiltner, U., Glatthorn, J., & Bugmann, H. (submitted). Bridging data gaps in forestry: A practitioner-informed Neural Network for predicting stem size distributions from aggregated data. Journal of Applied Ecology.
Marano, G., Hiltner, U., Meusburger, K., Hands, T., Bugmann, H. (in review). Predicting drought-induced tree mortality in Swiss beech forests hinges upon predisposing and inciting factors. Ecosphere.

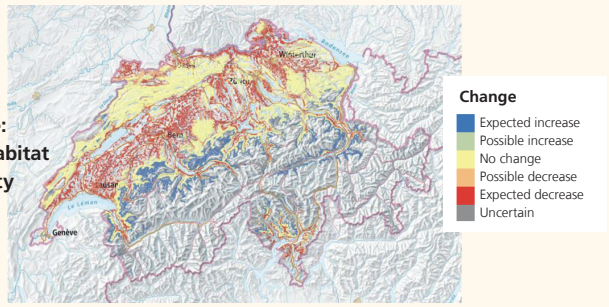
AVAILABLE INDICATORS IN THE FORTE APP

Habitat suitability

Indicator for the distribution of tree species

The app shows how habitats for different tree species will change under future climate scenarios. It highlights the regions where conditions for certain species will improve or deteriorate. It also shows how extreme weather events can influence the distribution of species.

Example:
Beech habitat suitability
RCP 8.5*

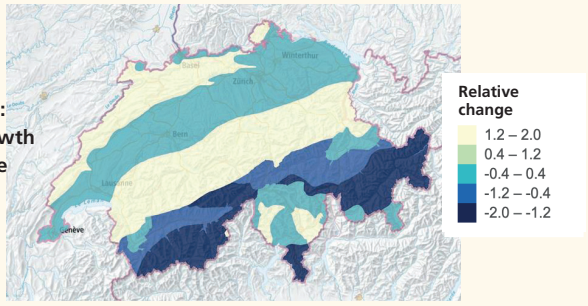


Forest health

Indicator of the resilience of Swiss forests

The app illustrates how climate change affects forest health. The maps provide information about the condition of forests under different climate scenarios and provide an important basis for the development of sustainable management strategies.

Example:
Tree growth resilience
RCP 8.5*

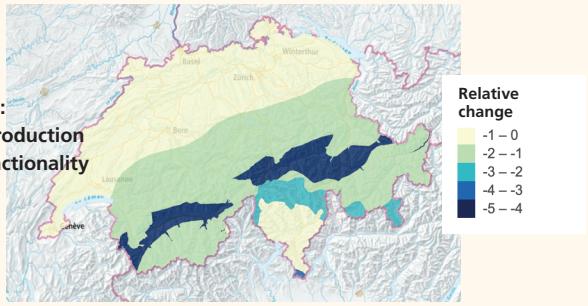


Multifunctionality and forest services

Indicators for climate-related changes

The app shows how key ecosystem services such as wood production, carbon storage, and protection against natural hazards could change in the future. The maps help to assess the effectiveness of different adaptation strategies.

Example:
Wood production Multifunctionality
RCP 8.5*



*Climate scenario without global climate protection
Relative change in the period 2045-2074 compared to the reference period 1981-2010

Scientific basis of the FORTE app

FORTE Forest Tree Explorer is based on the FORTE platform developed by WSL and Swiss-ForestLab. The app uses forest ecosystem models with updated Swiss climate scenarios to project the distribution of tree species and ecosystem services such as wood yield, protection against natural hazards, and habitat for native biodiversity. In addition, the multifunctionality mapping approach (according to Van der Plas et al. 2018) is used, which enables a spatially explicit assessment of multifunctionality and forest services. This method supports the identification of synergies and trade-offs between ecosystem services, thus improving the assessment of adaptation strategies under future climate conditions.

The app is still based on the older generation of climate scenarios (CH2018 climate scenarios). The new climate scenarios CH2025 climate scenarios vare now available. However, the main qualitative statements in both climate scenarios remain unchanged.

Technical report
CH2018 Climate Scenarios for Switzerland
SOMA-CH High-Resolution Soil Maps
Swiss National Forest Inventory (NFI)
EU-Forest – High-Resolution Tree Occurrence Dataset for Europe

WHAT ARE ECOSYSTEM SERVICES?

Ecosystem services are benefits that humans derive from natural processes, such as trees purifying the air. These services ensure food, health, climate, and quality of life – often unnoticed, but indispensable. The cross-sectoral dashboard developed as part of this project shows how ecosystem services from forests, agriculture, and water bodies change over time and under different climate scenarios. It thus provides a unique overview for the whole of Switzerland.

Further information

WSL dossier "Forests and climate change"
A comprehensive collection of fact sheets and research results that brings together practical information on adapting Swiss forests to climate change.

FOEN implementation guide "Sustainable forest management"
Provides a framework and recommendations for forest management that takes ecological, social, and economic aspects into account under changing climatic conditions.

NaiS – Sustainability and performance monitoring in protective forests
NaiS shows how a sustainably effective protective forest can be ensured with as little maintenance as possible.

Tree-App
The Tree-App supports forestry practice with tree species recommendations in the context of climate change.

Imprint

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More information about the programme	*NCCS-Impacts programme*

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Learn more about the project:
www.nccs-impacts.ch/ecosystems