

Forest reserve monitoring in Switzerland

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This document provides an overview of the forest reserve monitoring (FRM) in Switzerland. It introduces the monitoring methods applied and describes the metadata presented in the file metadata.csv.

Introduction

Long term monitoring of natural forests provides insights into ecological processes shaping forests without human intervention. To study natural forest dynamics, the former chair of silviculture at the Swiss Federal Institute of Technology (ETH) initiated a network of forest reserves in the late 1940's (Leibundgut 1957).

Since 2006, the monitoring is carried out in a cooperation project of the chair of Forest Ecology at ETH, the Swiss Federal Research Institute for Forest, Snow and Landscape Research (WSL) and the Federal Office for the Environment (FOEN). The project relaunch led to a streamlining of the reserve network, which now contains 33 of the original reserves and 16 new reserves.

The main goal is to evaluate the effectiveness of the federal reserve policy by analysing to what extent forest reserves differ from managed forests in terms of structure, dynamics, and habitat quality.

The monitoring covers all forest types in Switzerland and the reserves of the network are spread all over Switzerland (Figure 1). Whilst most of the reserves established in the early years of the network are rather small (several ha), the reserves added to the network after 2006 are larger (> 30 ha). This increase in reserve area reflects both the change in research focus as well as the increased willingness of forest owners to establish reserves due to the decreasing value of timber. While in the beginning, the research focused on the development of forests towards the presumed climax state, recently the effects of large-scale disturbances such as windthrow and insect outbreaks on forest succession have received increasing attention (Bugmann and Brang 2009).

The dataset has been used to investigate the development of stand structure in reserves dominated by European beech (*Fagus sylvatica*) (Heiri et al. 2009), Norway spruce (*Picea abies*) (Heiri et al. 2012) and oak species (*Quercus sp.*) (Rohner et al. 2012). Beyond analysing stand structure, the data has been used to model tree mortality for various species (Hülsmann et al. 2018, Wunder et al. 2007) and for the recalibration of the dynamic vegetation model FORCLIM (Cailleret et al. 2020).

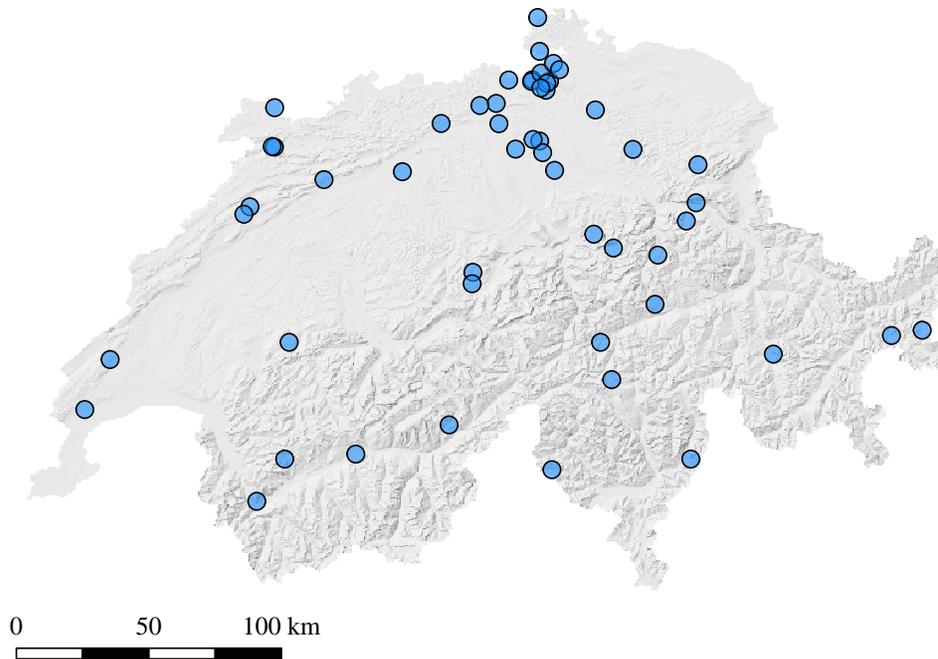


Figure 1: Position of reserves of the network within Switzerland.

Monitoring methods

The original monitoring scheme distinguished three levels of observation with increasing accuracy (Wunder et al. 2007): *compartment*, *permanent plot* and *strip transects*. Since 2006, sample plots have been established in larger reserves whilst the strip-transects are no longer monitored. The inventory interval for all monitoring types is approximately 10 years.

Compartment: Every reserve is subdivided into compartments. In these compartments, every tree with a Diameter at Breast Height (DBH) ≥ 4 cm was measured and rounded to the nearest cm and its status (alive / dead) recorded. This data allows for the analysis of structural dynamics (e.g., DBH distribution, species composition) at the compartment level.

The size of the compartments ranges from 0.04 to 88.31 ha with a median of 0.93 ha. In total all compartments cover 556 ha.

Permanent Plot: Every tree with a DBH ≥ 4 cm is stem-tagged (and after 2006 stem-mapped, see figure 2). In addition to measuring the trees' DBH to the nearest mm, further tree characteristics such as social position, vigor and crown length were assessed. Since 2006, inventories include measurements of all lying deadwood on selected permanent

plots. The measurements follow a protocol developed by Leibundgut (1959) and are documented in Tinner et al. (2013).

The size of the permanent plots ranges from 0.03 to 3.47 ha with a median of 0.37 ha. In total all permanent plots cover an area 143 ha.

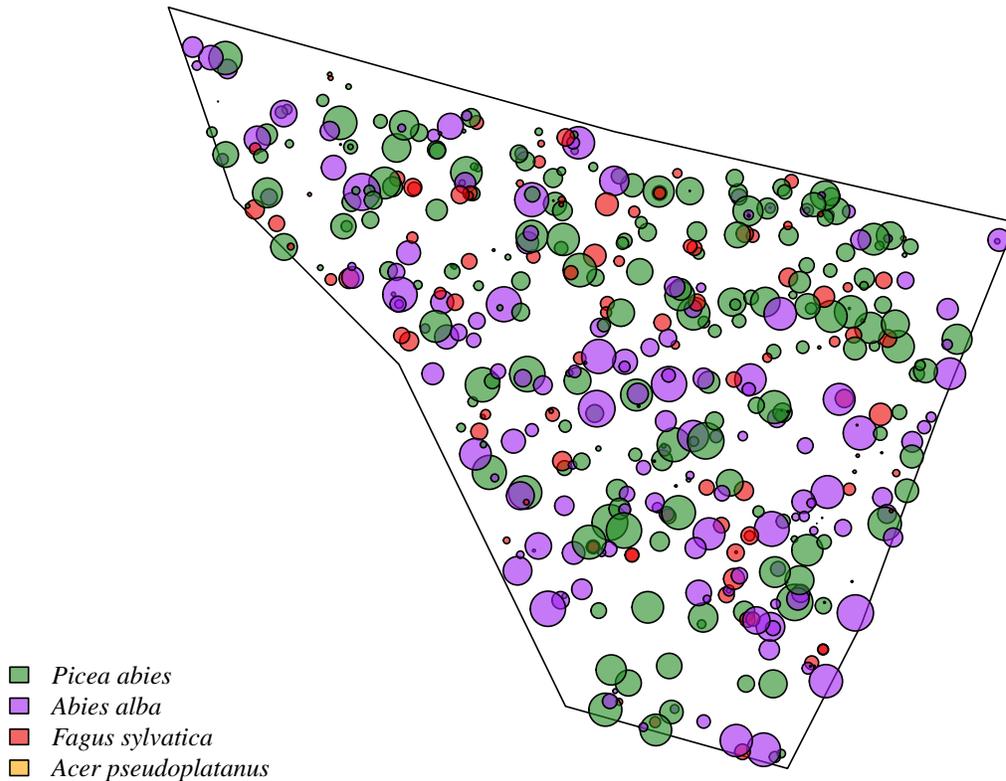


Figure 2: Tree positions in permanent plot nr 13, reserve Leihubelwald. The size of the points reflects the log of DBH measured in 2011. The plot covers an area of 0.53 ha.

Sample plots: Sample plot inventories are used in large reserves (size \geq ca 30 ha) to gain representative information. Sample plots are distributed on a regular grid covering the whole reserve or parts of it. On sample plots, all trees with DBH \geq 7 cm are measured on circular plots with 200 m² area, and those with dbh \geq 36 cm on plots with 500 m² area following Tinner and Brang (2013). Besides standing trees, regeneration up to DBH < 7 cm is surveyed on a subplot and dead wood is assessed on line intersects (Böhl and Brändli 2007). Up to 2019 1704 sample plots were established and measured at least once.

Data storage

All measurement data is stored in a PostgreSQL database at the Swiss Federal Research Institute WSL. The data is available on reasonable request.

Metadata

The .csv metadata contains the columns described in table 1. The values temp, precip and ele in the metadataset refer to the center of the reserve as defined by the columns lat and long.

Table 1: Metadata table contents

Column Name	Description	Type
reserve	Reserve number	numeric
name	Name of the reserve	character
area	Area of the reserve in ha	numeric
old-growth	Is the reserve considered to be old-growth/primary according to the definition with 1: old-growth, 2: not old-growth	boolean
lat	latitude of the center of the reserve	numeric
long	longitude of the center of the reserve	numeric
temp	mean annual temperature in deg C for reserve covering the period between 1981 and 2010. The data has been downscaled to a 100 m resolution by the Landscape Dynamics group at WSL using station data from MeteoSwiss. The value has been extracted at the centre defined by Lat/Long.	numeric
precip	Mean annual precipitation in mm for reserve covering the period between 1980 and 2010. The data has been downscaled to a 100 m resolution by the Landscape Dynamics group at WSL using station data from MeteoSwiss.	numeric
ele	Elevation of the reserve in m. The elevation was derived from the digital elevation model DHM 25 (swisstopo)	numeric
alt_zones	Altitudinal Zone the centre of the reserve. Plots might lie in other zones - especially in larger reserves	character
domspecies	Dominant tree species	character
invtype	Inventory type. 1: Permanent plot inventory, 2: Sample plot inventory, 3: Full cruise.	numeric
invtypename	Name of inventory type	character
aj	Measurement year	character
nPlots	Number of plots by reserve and invtype. <i>Please note: Not all plots need to have been measured throughout all inventories stated in colum aj</i>	numeric

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