



Swiss National Forest Inventory: To See the Wood for the Trees

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Introduction and intention

Thirty percent of Switzerland is covered by forests. For the sustainable use and protection of these forests it is necessary to provide objective and statistically reliable information to stakeholders (e.g. politicians, scientists and foresters). In the National Forest Inventory (NFI) the state and the changes of the Swiss forest are recorded. Since 1981 a vast amount of data has been collected in three inventory cycles (the fourth has recently started).

The SAS System, as part of NAFIDAS (presented here), assists digesting the collected data and drawing conclusions on the state of the Swiss forest.

NFI Data

NFI data is obtained from various sources, such as terrestrial forest surveys, aerial photo interpretation and GIS data. Raw data and variables derived from it are stored in an Oracle database, along with additional information on the derivation method.

The NAFIDAS package

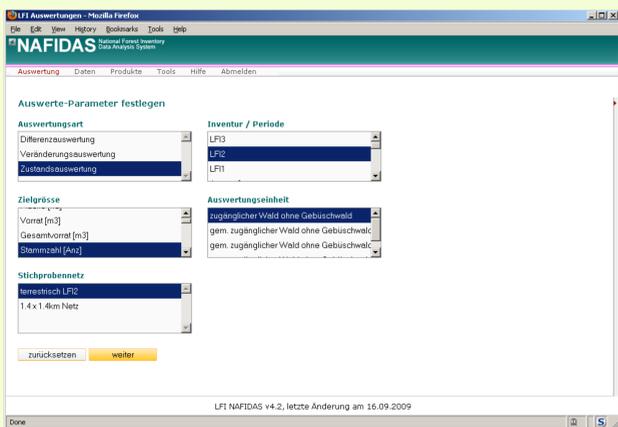
The main purpose of the National Forest Inventory Data Analysis System is to summarize collected data in reports. In addition, NAFIDAS allows the user to retrieve information about each variable, to determine how each variable was derived, how its values are distributed and how it depends on or affects other derived variables. As reports are generated in real-time, the calculated results are based on most recent data.

The NAFIDAS package is based on a client/server architecture with multiple tiers, where the user interface, the application logic, the statistical analysis and the data storage are functionally separated and distributed over several computers. The user interface runs in a Firefox browser at the client's computer, the Oracle database at one dedicated server and the web application and SAS at another.

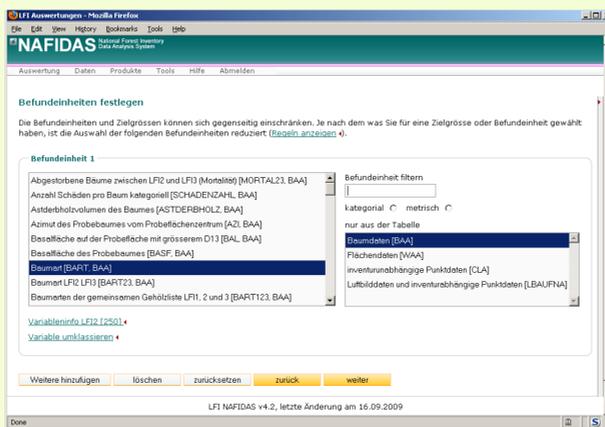
After logging on into NAFIDAS, the user selects the parameters that define structure and content of a result table:

Three-Step Parameter selection

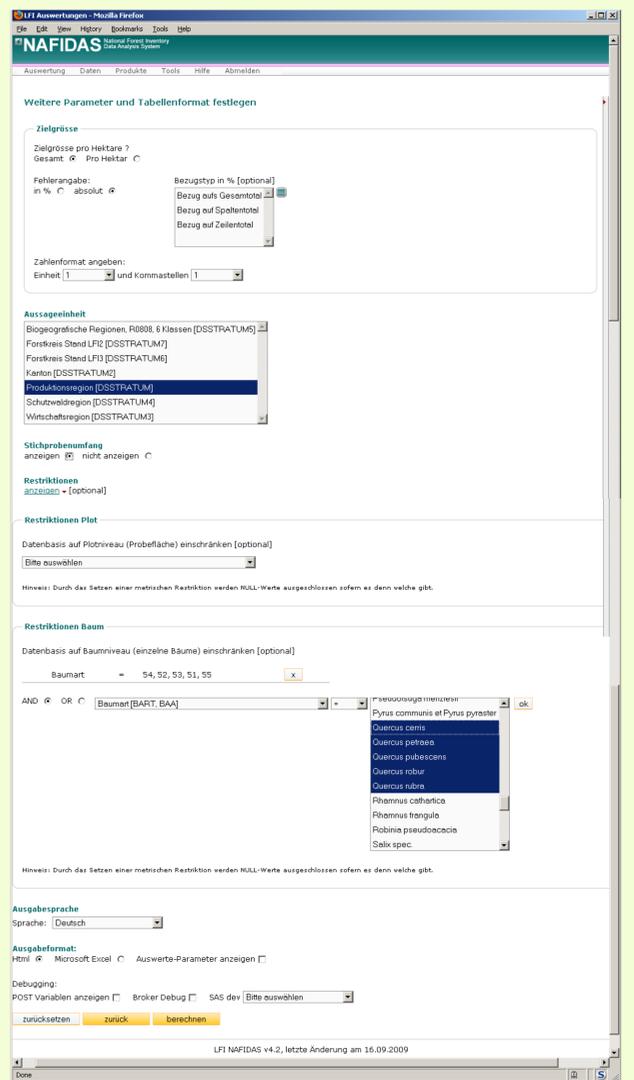
Step 1: Target variable (e.g., number of trees) and constraining variables (e.g., inventory and grid)



Step 2: Up to three grouping variables (e.g., tree species), that will set the rows of the table



Step 3: Column variable (e.g., region), restrictions (e.g., oak) and formatting variables



Result table

Reports present estimates with standard error using the double sampling technique. Estimates may be expressed as totals, mean spatial densities (per ha) or fractions of row or column totals. In addition to HTML the resulting table can be exported to Excel.

Baumart	Jura		Mittelland		Voralpen		Alpen		Alpenseite		Schweiz							
	Anz	N	Anz	N	Anz	N	Anz	N	Anz	N	Anz	N						
Quercus robur (Stieleiche)	594973.2	121764.4	1103	1787994.1	233439.7	1310	256760.1	69528.9	1217	237202.2	104664.5	2012	203163.3	67196.1	770	3040089.0	299374.2	6412
Quercus petraea (Traubeneiche)	2484690.4	447816.0	1103	2438936.8	478933.9	1310	91439.0	40430.4	1217	665693.3	166774.4	2012	1333612.1	340192.3	770	7014371.7	758250.8	6412
Quercus subescens (Blaueneiche)	9079.4	9079.4	1103	164490.0	100547.5	1310	0.0	0.0	1217	256025.1	116430.4	2012	644956.2	185504.1	770	1174560.8	241164.0	6412
Quercus cerris (Zerreiche)	0.0	0.0	1103	0.0	0.0	1310	0.0	0.0	1217	0.0	0.0	2012	65252.1	34288.2	770	65252.1	34288.2	6412
Quercus rubra (Roteiche)	94426.2	90864.0	1103	45594.2	22296.1	1310	0.0	0.0	1217	0.0	0.0	2012	0.0	0.0	770	140020.4	93599.5	6412
Total	3143169.2	471019.0	1103	4437005.2	541403.3	1310	348199.1	80234.6	1217	1258930.6	233126.5	2012	2249663.9	393929.5	770	11434288.0	854951.7	6412

SAS

Once the parameters have been selected, they are posted to the SAS application server. The SAS scripts are grouped into four modules:

- The **Import** module transfers from Oracle only the variables needed for the current report by analyzing the parameters received from the web server
- The **Combine** module creates one analysis dataset from the imported datasets. This includes reclassification of variables, if desired (e.g. reclassify the five oak species to one: *Quercus sp.*)
- The **Statistics** module analyzes the analysis dataset and creates a dataset for reporting purposes.
- The **Reporting** module creates the report table.

Additional scripts are used for logging, debugging and error reporting. The scripts use SQL (Pass-Through), Data Step and PROCs CORR and REPORT.

References

Köhl, M. (2001) Error sources and their influence on the NFI inventory results. In: Brassel, P; Lischke, H. (eds) Swiss National Forest Inventory: Methods and models of the second assessment. Birmensdorf, Swiss Federal Research Institute WSL. 336 pp.

Double Sampling for Stratification

There are more than 500 million trees in the Swiss forests, far too many to investigate individually. However, a randomised double sampling for stratification technique (Köhl 2001) yields adequate information. The intersections of a 500m-grid mapped over Switzerland define the total number of sample plots. In a first step aerial photos of all plots (x; mostly binomial distribution) are evaluated to decide whether a plot is forest or non-forest. In a second step conditions on forest plots (y) on a 1.41x1.41 km sub-grid are surveyed by field crews. Sampling error must be taken into account. The double sampling technique allows estimating the standard error of totals, mean spatial densities and ratios. For the latter, the covariance of the variable in the nominator and the denominator has to be calculated.

For each cell in the reports the values are calculated mainly using data step syntax, rather than using SAS/STAT procedures, e.g.

$$covyx = c1 - 1 / (n - 1) * x * y ; /* c1 includes the covariance from PROC CORR */$$

$$var_y = ymean ** 2 * (y_var / y ** 2 + x_var / x ** 2 - 2 * covyx / (Nt * y * x)) ; /* doub. smpl. variance */$$