

Calculation of emission factors for living biomass in Swiss forests for the Swiss GHGI 2017

Internal documentation of data delivery and more recent data

Esther Thürig, Erik Rösler, Markus Didion

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Summary

For the last two Swiss Greenhouse Gas Inventories (GHGI; FOEN 2015; FOEN 2016), forest emission factors for the years 2006 to 2013 were calculated based on data from National Forest Inventory (NFI) 3 (2004-2006) and NFI4b (2009 to 2013). For the most recent Swiss GHGI 1990-2015 (FOEN 2017), additional NFI4 data from the years 2014 and 2015 were available for calculating emission factors for the years 2006 to 2015. To restrict the reporting years to the most recent NFI, data from the years 2011 to 2015 were selected. Hence, the number of available sample plots for calculating emission factors remained approximately the same as for FOEN 2015 with 3280 plots or five years of data sampling. Data and data derivations of all NFI4b inventory years 2009-2013 were checked for consistency and plausibility. Therefore, differences between data for FOEN 2015 and FOEN 2017 are caused by 1) data and derivations plausibility and consistency check for the data years 2009-2013 and 2) by selecting the five most recent data years 2011 to 2015.

Plausibility checks of single tree measurements and consistency checks of data derivations and data deliveries resulted in no changes of the estimates of biomass in growing stock for national estimates and only very small changes of cut and mortality (+0.2%) and gross growth (+0.2%).

All other differences between NFI4 data for FOEN (2015) and FOEN (2017) are caused by the new data period 2011-2015 (FOEN 2017) compared to 2009-2013 in FOEN (2015). Overall, estimations of biomass in growing stock was $1.84 \text{ t} \pm 4.9 \text{ t}$ per ha higher in the NFI4 (2011-2015) than in the NFI4b (2009-2013). This is an increase of $+0.75\% \pm 2\%$. Cut and mortality increased by $0.45 \pm 0.44 \text{ t}$ per ha and year mainly due to an increase of losses of conifers in the Pre-Alps and deciduous trees below 600 m in the Plateau. This is an increase of $+8.8\% \pm 8.6\%$. Gross growth increased by $0.13 \pm 0.13 \text{ t}$ per ha and year mainly caused by an increase of gross growth of deciduous trees in the Alps, Pre-Alps and Southern Alps and increase of growth of all trees in the Jura. This is an increase of $+2.1\% \pm 2.1\%$. However, all changes are within two standard errors or slightly above and therefore have to be interpreted with caution.

1 Introduction

Due to the continuous inventory approach implemented with the National Forest Inventory (NFI)⁴, the Swiss GHGI can be provided with most recent forest data. For the Swiss Greenhouse Gas Inventory (GHGI) 1990-2015 (FOEN 2017), forest emission factors for the years 2006 to 2015 were calculated based on data from the NFI3 (2004-2006) and NFI4 (2011-2015) (see appendix). The number of available sample plots for calculating emission factors was 3280. Forest emission factors for biomass in growing stock, cut and mortality and gross growth are linearly interpolated to an annual basis. This report describes and analyzes changes between the estimation of emission factors for the forestry sector reported in FOEN (2015, 2016) and FOEN (2017).

1.1 TCCCA criteria and verification: specific information for UNFCCC/KP reviewers

This report addresses the criteria for transparency, consistency, comparability, completeness and accuracy (TCCCA):

Transparency is achieved by detailing the various data sets that were used and by providing relevant metadata and references. The methodology is described and referenced in section 2, data sets are compared in section 3 and displayed in the appendix.

Consistency is obtained by relying on data sources that are measured and maintained in a consistent manner (Swiss NFI) and that will be available in the future (regulated by law). It was ensured that the methods were applied consistently and that results are reported correspondingly, including data per unit area, which are independent of temporal changes in the underlying forest area. See section 2.

Comparability is achieved by applying the default method of IPCC to report carbon stock changes by the difference of gains and losses.

Completeness is reached by calculating annual estimates since 1990 for standing stock, gains and losses for all forest regions in Switzerland defined for the GHGI (see section 2.1). Each of the NFIs (1, 2, 3 and 4) are representative random samples for the forest regions in Switzerland defined in the GHGI.

Accuracy is obtained by employing reliable and accurate data and a methodology reported in Brassel and Lischke (2001).

2 Data and methods

NFI4b data are documented and published in Abegg et al. (2014). Metadata are available under <http://www.lfi.ch/dienstleist/daten-en.php>. The methods of data analysis are published in Brassel and Lischke (2001). Calculation of biomass is documented in Thürig and Herold (2013).

2.1 Spatial stratification

The NFI4 2011-2015 data include approximately 55% of all NFI4 plots of the accessible forest in Switzerland (3280 out of ca. 6000). Due to the large variability between sample plots, a minimum number of sample plots is needed to obtain reliable and representative estimates of means and sampling errors. Small strata did not include a sufficient number of plots (Table 1) and were merged with neighboring strata for the most recent GHGI (FOEN 2017). The following strata were aggregated and treated as single strata:

- Plateau 601-1200 and >1200: new stratum Plateau > 600 m (276 plots)
- Pre-Alps \leq 600 and 601-1200 m: new stratum Pre-Alps \leq 1200 m (400)
- Alps West \leq 600 and 601-1200 m: new stratum Alps West \leq 1200 m (142)
- Alps East \leq 600 and 601-1200 m: new stratum Alps Est \leq 1200 m (162)

Table 1 Number of sample plots by spatial strata in NFI4 2011-2015.

| Alt | Jura | Plateau | Pre-Alps | Alps West | Alps East | Southern Alps | Switzerland |
|------------|------|---------|----------|-----------|-----------|---------------|-------------|
| \leq 600 | 138 | 350 | 24 | 14 | 6 | 54 | 586 |
| 601 - 1200 | 354 | 267 | 376 | 128 | 156 | 150 | 1431 |
| >1200 | 74 | 9 | 208 | 342 | 398 | 232 | 1263 |
| Total | 566 | 626 | 608 | 484 | 560 | 436 | 3280 |

2.2 Time series consistency and accuracy

Data, data base and derivations of the Swiss NFI are under a continuously checked for plausibility and consistency and small inconsistencies are corrected. To guarantee time series consistency and accuracy, older data deliveries are always compared with the most recent data delivery. In this case, data delivered for FOEN (2015, 2016) were compared to recalculated data with the adjusted data base. Recalculated results of the adjusted data base are displayed in appendix A1 to A3. Comparisons between recalculated data and data delivered for FOEN (2015, 2016) resulted in no changes of the estimates of biomass in growing stock for national estimates and only very small changes of cut and mortality (+0.2%) and gross growth (+0.2%). Those small changes result from the small adjustments and corrections of data and data derivations and substantiate the high consistency and accuracy of the time series.

3 Result: Comparison between NFI data 2009-2013 and 2011-2015

To analyze differences between data delivered for the FOEN 2015 and FOEN 2016 (NFI 2009-2013) and the FOEN 2017 (NFI 2011-2015), recalculated results of FOEN (2015,2016) were compared with



the new data years 2011-2015 delivered for FOEN (2017). Comparisons were done on the original level of 15 strata without aggregated strata (see Table 1). As time series were checked for consistency (see section 2.2), the observed differences resulted from the new time period of data selection only.

Table 2 Biomass of living trees Difference of estimates between data delivery for FOEN 2015 and FOEN 2017. Positive numbers indicate an increase, negative number a decrease in the estimate for 2017 compared to 2015. The columns 'SE' contain twice the standard error which was estimated for the data prepared for the FOEN 2017. Bold figure indicates changes larger than twice the standard error. Except for the aggregated strata, the original biomass estimates are shown in Tables A1 and A4. Data are stratified by 5 NFI-regions, 3 elevation levels (meter above sea level from DEM25) and conifers (Con) or deciduous (Dec) trees.

| | | Jura | | Plateau | | Pre-Alps | | Alp West | | Alp East | | Southern Alps | | CH | |
|------------|-----|------------|--------|------------|--------|------------|--------|------------|--------|--------------|-------------|---------------|--------|------------|--------|
| Elevation | | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE |
| ≤ 600 | Con | -3.90 | 16.9 | -5.90 | 12.4 | -4.61 | 48.2 | 10.70 | 29.4 | 8.85 | 80.9 | 12.56 | 18.8 | -2.17 | 10.4 |
| | Dec | 18.40 | 29.9 | 10.36 | 17.2 | 69.86 | 81.3 | 11.16 | 69.6 | 101.57 | 155.3 | -5.02 | 31.0 | -5.63 | 12.7 |
| | All | 14.50 | 25.7 | 16.25 | 19.8 | 74.47 | 79.9 | 21.86 | 69.8 | -92.72 | 174.6 | 7.54 | 30.1 | -7.80 | 14.7 |
| 601 - 1200 | Con | 2.57 | 16.6 | 7.66 | 19.0 | 17.31 | 20.5 | 7.87 | 23.7 | 0.47 | 25.5 | -8.44 | 10.1 | 6.92 | 8.9 |
| | Dec | 3.76 | 14.0 | -9.39 | 20.1 | -7.42 | 15.0 | 13.41 | 26.8 | -10.49 | 17.4 | 25.14 | 40.0 | -2.60 | 7.5 |
| | All | 6.33 | 16.7 | -1.74 | 24.1 | 9.90 | 18.8 | -5.54 | 31.6 | -10.03 | 28.6 | 16.69 | 40.6 | 4.32 | 10.9 |
| >1200 | Con | 9.19 | 24.4 | 55.72 | 60.8 | -9.53 | 23.7 | 4.89 | 20.1 | 20.84 | 16.9 | -5.54 | 17.3 | 4.71 | 7.9 |
| | Dec | 7.97 | 17.3 | -0.64 | 10.8 | -5.32 | 9.5 | -1.10 | 4.5 | -1.39 | 4.1 | 2.80 | 9.4 | -0.67 | 3.2 |
| | All | 17.17 | 24.8 | 56.37 | 57.1 | 14.84 | 26.4 | 3.79 | 17.0 | 19.45 | 17.7 | -2.74 | 17.8 | 4.04 | 8.7 |
| Total | Con | 2.91 | 12.4 | -0.24 | 12.8 | 5.46 | 17.0 | 7.24 | 13.7 | 15.99 | 15.6 | -1.83 | 12.0 | 4.98 | 6.2 |
| | Dec | 6.82 | 11.2 | 10.32 | 14.1 | -6.36 | 9.9 | -5.10 | 8.8 | -7.16 | 6.2 | 6.97 | 16.3 | -3.13 | 5.5 |
| | All | 9.74 | 10.6 | 10.57 | 16.2 | -0.90 | 17.7 | 2.13 | 16.6 | 8.83 | 13.6 | 5.14 | 15.0 | 1.84 | 4.9 |

The difference between the estimate of biomass in growing stock for FOEN 2017 (based on NFI 2011-2015) and FOEN 2015 (based on NFI4b 2009-2013) was generally closely within two standard errors of the values for the FEON 2017 (Table 2). In the Alp East, there is a trend to an increase in biomass for both, conifers and deciduous trees. Overall, estimation of biomass in growing stock was $1.84 \text{ t} \pm 4.9 \text{ t per ha}$ (2SE) higher in the NFI 2011-2015 than in the NFI 4b (2009-2013). This is a plus of $+0.75\% \pm 2\%$.

The difference between the estimate of biomass in cut and mortality for FOEN 2017 (based on NFI 2011-2015) and FOEN 2015 (based on NFI4b 2009-2013) was generally closely within two standard errors of the values for the FOEN 2017 (Table 3). An exception could be observed for the conifers within the elevation level 601 and 1200 in the Pre-Alps with an increase in cut and mortality by $1.50 \pm 1.29 \text{ t biomass per ha}$. Overall, cut and mortality increased by $0.45 \pm 0.44 \text{ t biomass per ha}$ and year mainly due to an increase of losses in the Pre-Alps between 601 and 1200 m and the Plateau below 600 m.

The difference between the estimate of biomass in gross growth for FOEN 2017 (based on NFI 2011-2015) and FOEN 2015 (based on NFI4b 2009-2013) was generally closely within two standard errors of the values for the FOEN 2017 (Table 4). Gross growth increased by 0.13 ± 0.13 t per ha and year. However, all changes are within two standard errors or slightly above and can therefore not be interpreted as real effects.

Table 3 Annual cut and mortality in biomass Difference of estimates between data delivery for FOEN 2015 and FOEN 2017. Positive numbers indicate an increase, negative number a decrease in the estimate for 2017 compared to 2015. The columns 'SE' contain double the standard error which was estimated for the data prepared for the FOEN 2017. Bold figure indicates changes larger than twice the standard error. Except for the aggregated strata, the original biomass estimates are shown in Tables A2 and A5. Data are stratified by 5 NFI-regions, 3 elevation levels (meter above sea level from DEM25) and conifers (Con) or deciduous (Dec) trees.

| | | Jura | | Plateau | | Pre-Alps | | Alp West | | Alp East | | Southern Alps | | CH | |
|------------|-----|------------|--------|------------|--------|-------------|-------------|------------|--------|------------|--------|---------------|--------|-------------|-------------|
| Alt | | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE |
| ≤ 600 | Con | -0.18 | 1.23 | 0.34 | 1.30 | 0.45 | 1.69 | 1.23 | 2.66 | 0.03 | 6.15 | 0.33 | 0.66 | 0.26 | 0.81 |
| | Dec | 0.19 | 1.34 | 1.09 | 1.24 | -1.69 | 2.60 | -1.22 | 1.70 | -3.07 | 9.32 | 0.52 | 1.34 | 0.62 | 0.84 |
| | All | 0.01 | 1.81 | 1.44 | 1.77 | -1.24 | 2.98 | 0.01 | 3.91 | -3.04 | 15.25 | 0.86 | 1.46 | 0.87 | 1.11 |
| 601 - 1200 | Con | 0.70 | 0.90 | -0.08 | 1.46 | 1.50 | 1.29 | 0.17 | 1.06 | 0.90 | 1.52 | 0.08 | 1.28 | 0.69 | 0.55 |
| | Dec | -0.32 | 0.74 | -0.22 | 1.10 | 0.46 | 0.78 | 0.48 | 1.26 | 0.07 | 0.90 | -0.49 | 0.50 | 0.01 | 0.38 |
| | All | 0.38 | 1.31 | -0.30 | 1.85 | 1.96 | 1.55 | 0.65 | 1.65 | 0.97 | 1.76 | -0.41 | 1.36 | 0.70 | 0.70 |
| >1200 | Con | 0.06 | 0.78 | 0.25 | 1.14 | -0.59 | 1.04 | 0.26 | 0.72 | 0.25 | 0.68 | 0.02 | 0.54 | 0.04 | 0.36 |
| | Dec | 0.09 | 0.37 | 0.00 | | -0.08 | 0.10 | 0.01 | 0.09 | 0.00 | 0.05 | 0.06 | 0.22 | 0.01 | 0.06 |
| | All | 0.15 | 0.96 | 0.25 | 1.14 | -0.67 | 1.03 | 0.28 | 0.76 | 0.26 | 0.66 | 0.08 | 0.58 | 0.05 | 0.39 |
| Total | Con | 0.39 | 0.69 | 0.15 | 0.98 | 0.73 | 0.89 | 0.28 | 0.61 | 0.41 | 0.67 | 0.09 | 0.53 | 0.35 | 0.29 |
| | Dec | -0.18 | 0.59 | 0.50 | 0.80 | 0.25 | 0.51 | 0.08 | 0.34 | -0.07 | 0.27 | -0.11 | 0.28 | 0.10 | 0.23 |
| | All | 0.21 | 0.99 | 0.65 | 1.27 | 0.98 | 1.03 | 0.35 | 0.72 | 0.34 | 0.74 | -0.02 | 0.59 | 0.45 | 0.44 |

Table 4 Annual gross growth of living trees in biomass Difference of estimates between the data delivery for FOEN 2015 and FOEN 2017. Positive numbers indicate an increase, negative number a decrease in the estimate for 2017 compared to 2015. The columns 'SE' contain double the standard error which was estimated for the data prepared for the FOEN 2017. Bold figure indicates changes larger than twice the standard error. Except for the aggregated strata, the original biomass estimates are shown in Tables A3 and A6. Data are stratified by 5 NFI-regions, 3 elevation levels (meter above sea level from DEM25) and conifers (Con) or deciduous (Dec) trees.

| | | Jura | | Plateau | | Pre-Alps | | Alp West | | Alp East | | Southern Alps | | CH | |
|------------|-----|------------|--------|------------|--------|------------|--------|------------|--------|--------------|-------------|---------------|--------|-------------|-------------|
| Alt | | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE | 1000 kg/ha | ± 2 SE |
| ≤ 600 | Con | 0.16 | 0.62 | -0.11 | 0.48 | 0.67 | 1.72 | 0.47 | 1.17 | 0.23 | 2.18 | 0.13 | 0.48 | 0.05 | 0.38 |
| | Dec | 0.28 | 0.82 | -0.13 | 0.61 | -0.01 | 2.11 | 0.48 | 2.93 | -7.06 | 2.78 | -0.26 | 1.04 | -0.11 | 0.40 |
| | All | 0.44 | 0.75 | -0.24 | 0.54 | 0.66 | 2.21 | 0.95 | 2.64 | -6.82 | 4.62 | -0.13 | 1.11 | -0.06 | 0.49 |
| 601 - 1200 | Con | 0.34 | 0.44 | 0.42 | 0.66 | 0.48 | 0.54 | 0.53 | 0.75 | -0.07 | 0.56 | -0.02 | 0.18 | 0.34 | 0.24 |
| | Dec | 0.06 | 0.36 | 0.05 | 0.62 | -0.07 | 0.45 | -0.12 | 0.69 | -0.10 | 0.51 | -0.65 | 1.19 | -0.08 | 0.25 |
| | All | 0.41 | 0.54 | 0.46 | 0.80 | 0.40 | 0.66 | 0.41 | 0.88 | -0.17 | 0.71 | -0.68 | 1.13 | 0.26 | 0.29 |
| >1200 | Con | 0.19 | 0.57 | -0.69 | 0.85 | -0.24 | 0.67 | 0.37 | 0.40 | 0.58 | 0.40 | -0.15 | 0.56 | 0.21 | 0.24 |

| | | | | | | | | | | | | | | | |
|--------------|-----|------|------|-------|------|-------|------|--------------|-------------|--------------|-------------|-------|------|-------------|-------------|
| | Dec | 0.22 | 0.46 | 0.09 | 0.19 | 0.02 | 0.21 | -0.35 | 0.11 | -0.04 | 0.11 | 0.09 | 0.32 | -0.08 | 0.08 |
| | All | 0.41 | 0.67 | -0.60 | 0.78 | -0.22 | 0.75 | 0.02 | 0.43 | 0.53 | 0.43 | -0.06 | 0.59 | 0.13 | 0.26 |
| Total | Con | 0.30 | 0.33 | 0.11 | 0.46 | 0.21 | 0.41 | 0.43 | 0.36 | 0.40 | 0.38 | -0.02 | 0.33 | 0.24 | 0.15 |
| | Dec | 0.09 | 0.33 | -0.07 | 0.38 | 0.02 | 0.30 | -0.29 | 0.24 | -0.21 | 0.17 | -0.29 | 0.50 | -0.11 | 0.15 |
| | All | 0.39 | 0.40 | 0.04 | 0.56 | 0.23 | 0.43 | 0.15 | 0.36 | 0.19 | 0.37 | -0.30 | 0.49 | 0.13 | 0.13 |

3.1 Uncertainty

Total uncertainty of net carbon stock change in living biomass in terms of carbon per unit area ($U_{liv.biom.}$) arises from different sources: 1) sampling error of measured NFI data (Köhl 1994) to estimate gains and losses in stem wood over bark from the NFI, 2) whole-tree biomass estimation, incl. biomass expansion, 3) variability in carbon content, and 4) variation in wood density. $U_{liv.biom.}$ is calculated as the sum of the single uncertainty components. In this report, we calculate the uncertainty of the random sample gains and losses in stem wood over bark. The other components are calculated in the most recent FOEN 2017. Total $U_{liv.biom.}$ is calculated by adding all *relative uncertainties* following equation 6.4 in chapter 'Quantifying Uncertainties in Practice' (IPCC 2000).

In Switzerland, gains and losses are estimated as random variables from the NFI. The uncertainty of gains and losses in stem wood over bark is approximated by sampling theory as the sample variance of the NFI plots (Brassel and Lischke 2001). Net change of stem wood over bark is calculated as the difference between gains and losses. The uncertainty of the two combined random variables is calculated by the law of error propagation (Eq. 1).

$$SE_{gains - losses} = (SE_{gains}^2 + SE_{losses}^2)^{0.5} \quad \text{Eq. 1}$$

where SE_{gains} and SE_{losses} are in absolute values. Absolute estimates for standing stock and its Standard Errors (SE) can be calculated from Abegg et al. 2014:

$$\text{Absolute values of gains} = 8.95 \pm 2\% = 8.95 \pm 0.179 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$$

$$\text{Absolute values of losses} = 7.64 \pm 4\% = 7.64 \pm 0.306 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$$

The net carbon stock change in stem wood over bark is calculated as the difference between gains and losses and results in 1.31 m^3 stem wood over bark per ha and year. The uncertainty of this estimate can be calculated with Eq. 1.

$$SE_{gains - losses} = (0.179^2 + 0.306^2)^{0.5} = \pm 0.35 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$$

Equation 1 assumes the random variables gains and losses to be independent. This may result in an overestimation of the error estimation. However, this is partly compensated by disregarding model errors in the estimation of stem wood volumes from the measured dbh, d7 and tree height.

In FOEN 2017, uncertainties of all four components are combined by adding *relative uncertainties* following equation 6.4 in chapter 'Quantifying Uncertainties in Practice' (IPCC 2000). Relative uncertainty is calculated as the ratio of $SE_{gains - losses}$ ($\pm 0.35 \text{ m}^3 \text{ ha}^{-1} \text{ year}^{-1}$) and the absolute sink value

(1.31 m³ ha⁻¹ Jahr⁻¹). This results in a relative uncertainty of the estimation of net carbon stock change in stem wood over bark of ±27%.

4 Literature

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Appendix

Recalculated data delivery FOEN 2015

A1 Biomass of living trees 2009-2013 of the common and accessible forest area NFI 3/2009-2013. Data are stratified for 5 NFI-regions, 3 elevation levels (meter above sea level from DEM25) and for conifers (Con) or deciduous (Dec) trees.

| | | Jura | | Plateau | | Pre-Alps | | Alp West | | Alp East | | Southern Alps | | CH | |
|------------|-----|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|
| Alt | | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % |
| ≤ 600 | Con | 74.5 | 12 | 109.57 | 6 | 104.98 | 36 | 25.16 | 49 | 75.4 | 41 | 3.34 | 74 | 88.65 | 6 |
| | Dec | 168.26 | 7 | 153.67 | 6 | 254.68 | 20 | 146.92 | 28 | 274.12 | 20 | 177.05 | 8 | 163.82 | 4 |
| | All | 242.76 | 5 | 263.23 | 4 | 359.66 | 14 | 172.08 | 24 | 349.52 | 18 | 180.39 | 8 | 252.47 | 3 |
| 601 - 1200 | Con | 135.99 | 5 | 150.8 | 6 | 187.94 | 5 | 100.08 | 10 | 158.86 | 8 | 29.57 | 23 | 140.91 | 3 |
| | Dec | 136.46 | 5 | 152.63 | 7 | 114.84 | 6 | 102.87 | 12 | 89.69 | 11 | 156.66 | 8 | 127.81 | 3 |
| | All | 272.45 | 3 | 303.44 | 4 | 302.77 | 3 | 202.95 | 7 | 248.55 | 6 | 186.24 | 6 | 268.72 | 2 |
| >1200 | Con | 143.38 | 9 | 234.47 | 16 | 246.98 | 5 | 195.95 | 5 | 190.55 | 4 | 149.65 | 7 | 192.49 | 2 |
| | Dec | 45.94 | 17 | 12.38 | 54 | 31.59 | 18 | 12.96 | 18 | 11.73 | 19 | 30.84 | 14 | 20.84 | 8 |
| | All | 189.32 | 7 | 246.85 | 15 | 278.57 | 5 | 208.91 | 4 | 202.28 | 4 | 180.49 | 5 | 213.33 | 2 |
| Total | Con | 120.93 | 4 | 128.36 | 4 | 206.67 | 4 | 164.26 | 4 | 179.57 | 4 | 87.86 | 7 | 150.54 | 2 |
| | Dec | 133.38 | 4 | 151.71 | 5 | 89.07 | 6 | 41.71 | 11 | 38.37 | 10 | 94.65 | 6 | 94.28 | 2 |
| | All | 254.31 | 2 | 280.08 | 3 | 295.74 | 3 | 205.98 | 4 | 217.94 | 3 | 182.51 | 4 | 244.83 | 1 |

A2 Annual cut and mortality of living trees in biomass LFI3/2009-2013, common and accessible forest area NFI 3/2009-2013. Data are stratified for 5 NFI-regions, 3 elevation levels (meter above sea level from DEM25) and for conifers (Con) or deciduous (Dec) trees.

| | | Jura | | Plateau | | Pre-Alps | | Alp West | | Alp East | | Southern Alps | | CH | |
|------------|-----|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|
| Alt | | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % |
| ≤ 600 | Con | 3.25 | 26 | 5.57 | 12 | 1.78 | 62 | 1.19 | 74 | 4.63 | 43 | 0.00 | . | 4.27 | 11 |
| | Dec | 4.29 | 18 | 4.06 | 13 | 4.78 | 61 | 2.64 | 85 | 7.38 | 52 | 3.19 | 21 | 4.07 | 10 |
| | All | 7.54 | 15 | 9.63 | 9 | 6.56 | 45 | 3.82 | 62 | 12.02 | 46 | 3.19 | 21 | 8.34 | 7 |
| 601 - 1200 | Con | 3.37 | 13 | 6.71 | 13 | 4.92 | 13 | 1.72 | 31 | 2.72 | 19 | 0.67 | 99 | 3.92 | 7 |
| | Dec | 2.79 | 15 | 3.88 | 14 | 1.71 | 21 | 1.37 | 38 | 1.48 | 28 | 1.81 | 28 | 2.34 | 8 |
| | All | 6.16 | 11 | 10.59 | 10 | 6.63 | 12 | 3.09 | 24 | 4.20 | 16 | 2.48 | 33 | 6.27 | 6 |
| >1200 | Con | 1.19 | 38 | 1.10 | 64 | 3.20 | 24 | 2.00 | 24 | 1.87 | 17 | 1.02 | 30 | 1.95 | 11 |
| | Dec | 0.44 | 45 | 0.00 | . | 0.18 | 40 | 0.11 | 37 | 0.07 | 34 | 0.29 | 38 | 0.16 | 18 |
| | All | 1.64 | 32 | 1.10 | 64 | 3.38 | 23 | 2.10 | 24 | 1.94 | 16 | 1.31 | 25 | 2.11 | 11 |
| Total | Con | 3.06 | 11 | 6.00 | 9 | 4.22 | 11 | 1.89 | 19 | 2.16 | 12 | 0.76 | 37 | 3.25 | 5 |
| | Dec | 2.88 | 12 | 3.94 | 9 | 1.25 | 19 | 0.53 | 31 | 0.60 | 24 | 1.21 | 18 | 1.84 | 6 |
| | All | 5.95 | 9 | 9.94 | 7 | 5.47 | 10 | 2.43 | 17 | 2.76 | 11 | 1.97 | 18 | 5.09 | 4 |

A3 Annual gross growth of living trees in biomass LFI3/2009-2013, common and accessible forest area NFI 3/2009-2013. Data are stratified for 5 NFI-regions, 3 elevation levels (meter above sea level from DEM25) and for conifers (Con) or deciduous (Dec) trees.

| | | Jura | | Plateau | | Pre-Alps | | Alp West | | Alp East | | Southern Alps | | CH | |
|---------------|-----|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|
| Alt | | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % |
| ≤ 600 | Con | 2.23 | 16 | 4.08 | 7 | 1.93 | 52 | 0.95 | 50 | 2.56 | 35 | 0.16 | 99 | 3.11 | 6 |
| | Dec | 4.86 | 9 | 5.19 | 7 | 5.29 | 29 | 3.59 | 36 | 9.90 | 30 | 5.00 | 16 | 5.12 | 5 |
| | All | 7.08 | 7 | 9.27 | 4 | 7.22 | 23 | 4.54 | 25 | 12.45 | 27 | 5.16 | 15 | 8.23 | 3 |
| 601 - 1200 | Con | 3.36 | 6 | 5.13 | 7 | 4.95 | 6 | 2.35 | 17 | 3.21 | 11 | 0.40 | 42 | 3.71 | 3 |
| | Dec | 2.96 | 8 | 4.39 | 8 | 2.90 | 9 | 2.14 | 27 | 2.06 | 15 | 4.61 | 14 | 3.21 | 5 |
| | All | 6.32 | 5 | 9.51 | 4 | 7.85 | 4 | 4.49 | 15 | 5.27 | 8 | 5.01 | 13 | 6.92 | 3 |
| >1200 | Con | 2.99 | 14 | 4.56 | 8 | 5.06 | 8 | 3.65 | 7 | 3.46 | 7 | 3.25 | 10 | 3.74 | 4 |
| | Dec | 0.81 | 35 | -0.07 | 114 | 0.51 | 27 | 0.62 | 29 | 0.34 | 21 | 0.50 | 36 | 0.50 | 14 |
| | All | 3.80 | 14 | 4.49 | 8 | 5.56 | 7 | 4.27 | 8 | 3.81 | 6 | 3.75 | 10 | 4.24 | 4 |
| Total | Con | 3.02 | 6 | 4.53 | 5 | 4.90 | 5 | 3.21 | 7 | 3.37 | 6 | 1.83 | 11 | 3.61 | 2 |
| | Dec | 3.18 | 6 | 4.79 | 5 | 2.11 | 8 | 1.13 | 18 | 1.00 | 13 | 2.55 | 11 | 2.55 | 3 |
| | All | 6.20 | 4 | 9.32 | 3 | 7.01 | 4 | 4.34 | 7 | 4.37 | 5 | 4.38 | 7 | 6.16 | 2 |

Data delivery FOEN 2017

A4 Biomass of living trees 2011-2015 of the common and accessible forest area NFI 3/2011-2015. Data are stratified for 5 NFI-regions, 3 elevation levels (meter above sea level from DEM25) and for conifers (Con) or deciduous (Dec) trees.

| | | Jura | | Plateau | | Pre-Alps | | Alp West | | Alp East | | Southern Alps | | CH | |
|---------------|-----|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|
| Alt | | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % |
| ≤ 600 | Con | 70.6 | 12 | 103.67 | 6 | 100.37 | 24 | 35.86 | 41 | 84.25 | 48 | 15.9 | 59 | 86.48 | 6 |
| | Dec | 186.66 | 8 | 143.31 | 6 | 184.82 | 22 | 158.08 | 22 | 172.55 | 45 | 172.03 | 9 | 158.19 | 4 |
| | All | 257.26 | 5 | 246.98 | 4 | 285.19 | 14 | 193.94 | 18 | 256.8 | 34 | 187.93 | 8 | 244.67 | 3 |
| 601 - 1200 | Con | 138.56 | 6 | 158.46 | 6 | 205.25 | 5 | 107.95 | 11 | 159.33 | 8 | 21.13 | 24 | 147.83 | 3 |
| | Dec | 140.22 | 5 | 143.24 | 7 | 107.42 | 7 | 89.46 | 15 | 79.2 | 11 | 181.8 | 11 | 125.21 | 3 |
| | All | 278.78 | 3 | 301.7 | 4 | 312.67 | 3 | 197.41 | 8 | 238.52 | 6 | 202.93 | 10 | 273.04 | 2 |
| >1200 | Con | 152.57 | 8 | 178.75 | 17 | 237.45 | 5 | 200.84 | 5 | 211.39 | 4 | 144.11 | 6 | 197.2 | 2 |
| | Dec | 53.91 | 16 | 11.74 | 46 | 26.27 | 18 | 11.86 | 19 | 10.34 | 20 | 33.64 | 14 | 20.17 | 8 |
| | All | 206.49 | 6 | 190.48 | 15 | 263.73 | 5 | 212.7 | 4 | 221.73 | 4 | 177.75 | 5 | 217.37 | 2 |
| Total | Con | 123.84 | 5 | 128.12 | 5 | 212.13 | 4 | 171.5 | 4 | 195.56 | 4 | 86.03 | 7 | 155.52 | 2 |
| | Dec | 140.2 | 4 | 141.39 | 5 | 82.71 | 6 | 36.61 | 12 | 31.21 | 10 | 101.62 | 8 | 91.15 | 3 |
| | All | 264.05 | 2 | 269.51 | 3 | 294.84 | 3 | 208.11 | 4 | 226.77 | 3 | 187.65 | 4 | 246.67 | 1 |

A5 Annual cut and mortality of living trees LFI3/2011-2015, common and accessible forest area NFI 3/2011-2015. Data are stratified for 5 NFI-regions, 3 elevation levels (meter above sea level from DEM25) and for conifers (Con) or deciduous (Dec) trees.

| | | Jura | | Plateau | | Pre-Alps | | Alp West | | Alp East | | Southern Alps | | CH | |
|-------|-----|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|
| Alt | | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % |
| ≤ 600 | Con | 3.07 | 20 | 5.92 | 11 | 2.23 | 38 | 2.41 | 55 | 4.66 | 66 | 0.33 | 99 | 4.53 | 9 |
| | Dec | 4.48 | 15 | 5.15 | 12 | 3.09 | 42 | 1.42 | 60 | 4.32 | 108 | 3.71 | 18 | 4.69 | 9 |

| | | | | | | | | | | | | | | | |
|-------------------|-----|------|----|-------|----|------|----|------|----|------|----|------|----|------|----|
| | All | 7.55 | 12 | 11.06 | 8 | 5.32 | 28 | 3.83 | 51 | 8.97 | 85 | 4.04 | 18 | 9.22 | 6 |
| 601 - 1200 | Con | 4.07 | 11 | 6.63 | 11 | 6.43 | 10 | 1.90 | 28 | 3.62 | 21 | 0.75 | 86 | 4.61 | 6 |
| | Dec | 2.47 | 15 | 3.66 | 15 | 2.17 | 18 | 1.85 | 34 | 1.55 | 29 | 1.32 | 19 | 2.35 | 8 |
| | All | 6.54 | 10 | 10.29 | 9 | 8.60 | 9 | 3.74 | 22 | 5.17 | 17 | 2.06 | 33 | 6.96 | 5 |
| >1200 | Con | 1.26 | 31 | 1.36 | 42 | 2.61 | 20 | 2.26 | 16 | 2.13 | 16 | 1.05 | 26 | 1.99 | 9 |
| | Dec | 0.53 | 35 | 0.00 | . | 0.11 | 49 | 0.12 | 39 | 0.07 | 33 | 0.34 | 32 | 0.16 | 17 |
| | All | 1.79 | 27 | 1.36 | 42 | 2.72 | 19 | 2.38 | 16 | 2.20 | 15 | 1.39 | 21 | 2.16 | 9 |
| Total | Con | 3.46 | 10 | 6.15 | 8 | 4.95 | 9 | 2.17 | 14 | 2.57 | 13 | 0.86 | 31 | 3.60 | 4 |
| | Dec | 2.70 | 11 | 4.44 | 9 | 1.50 | 17 | 0.61 | 28 | 0.53 | 26 | 1.10 | 13 | 1.94 | 6 |
| | All | 6.16 | 8 | 10.60 | 6 | 6.46 | 8 | 2.78 | 13 | 3.10 | 12 | 1.95 | 15 | 5.54 | 4 |

A6 Annual gross growth of living trees LFI3/2011-2015, common and accessible forest area NFI 3/2011-2015. Data are stratified for 5 NFI-regions, 3 elevation levels (meter above sea level from DEM25) and for conifers (Con) or deciduous (Dec) trees.

| | | Jura | | Plateau | | Pre-Alps | | Alp West | | Alp East | | Southern Alps | | CH | |
|-------------------|-----|------------|-----|------------|-----|------------|-----|------------|-----|------------|-----|---------------|-----|------------|-----|
| Alt | | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % | 1000 kg/ha | ± % |
| ≤ 600 | Con | 2.39 | 13 | 3.97 | 6 | 2.60 | 33 | 1.43 | 41 | 2.79 | 39 | 0.29 | 82 | 3.16 | 6 |
| | Dec | 5.14 | 8 | 5.06 | 6 | 5.28 | 20 | 4.07 | 36 | 2.84 | 49 | 4.74 | 11 | 5.01 | 4 |
| | All | 7.52 | 5 | 9.03 | 3 | 7.88 | 14 | 5.49 | 24 | 5.63 | 41 | 5.03 | 11 | 8.17 | 3 |
| 601 - 1200 | Con | 3.71 | 6 | 5.54 | 6 | 5.43 | 5 | 2.88 | 13 | 3.14 | 9 | 0.37 | 24 | 4.05 | 3 |
| | Dec | 3.02 | 6 | 4.44 | 7 | 2.82 | 8 | 2.02 | 17 | 1.96 | 13 | 3.96 | 15 | 3.13 | 4 |
| | All | 6.73 | 4 | 9.98 | 4 | 8.25 | 4 | 4.90 | 9 | 5.10 | 7 | 4.33 | 13 | 7.18 | 2 |
| >1200 | Con | 3.18 | 9 | 3.87 | 11 | 4.82 | 7 | 4.02 | 5 | 4.04 | 5 | 3.10 | 9 | 3.94 | 3 |
| | Dec | 1.04 | 22 | 0.02 | 425 | 0.52 | 20 | 0.27 | 21 | 0.30 | 18 | 0.60 | 27 | 0.42 | 10 |
| | All | 4.21 | 8 | 3.89 | 10 | 5.34 | 7 | 4.29 | 5 | 4.34 | 5 | 3.69 | 8 | 4.37 | 3 |
| Total | Con | 3.31 | 5 | 4.64 | 5 | 5.11 | 4 | 3.64 | 5 | 3.78 | 5 | 1.81 | 9 | 3.85 | 2 |
| | Dec | 3.28 | 5 | 4.72 | 4 | 2.13 | 7 | 0.84 | 14 | 0.79 | 11 | 2.26 | 11 | 2.44 | 3 |
| | All | 6.59 | 3 | 9.36 | 3 | 7.24 | 3 | 4.48 | 4 | 4.56 | 4 | 4.08 | 6 | 6.29 | 1 |