Development and implementation of forest accounts in Sweden

Deliverable 1.1 of Eurostat grant project 2023_SE_EGD

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Acronyms and abbreviations

EFA – European Forest accounts

EPA – Environmental Protection Agency

GDP – Gross domestic product

FFHI – Formal protected forest, Voluntary set-asides, Environmental consideration and Unproductive forest land

FRA – Forest Resources Assessment

FRIS – Forest Research Institute of Sweden

FAWS/FNAWS – Forest Available (Not Available) for Wood Supply

LULUCF – Land Use, Land Use Change and Forestry

NA – National Accounts

NFI – National Forest Inventory

NMD – National Land Cover Map

NPV – Net Present Value

OWL – Other wooded land

SEEA – System of Environmental-Economic Accounting

SFA – Swedish Forest Agency

SLU – Swedish University of Agricultural Sciences

SoEF – State of Europe’s Forests

1. Summary

The work presented in this report, has been made by Statistics Sweden, the Swedish Forest Agency (SFA) and the Swedish University of Agricultural Sciences (SLU).

1.1. Introduction

This report is the result of a Eurostat grant financed project, where one of the work packages had the objective to set up a production process for the reporting of the Swedish Forest Account, according to the amendment of Regulation 691/2011 on environmental accounts. The aim was to provide the full accounts reporting requirements, preparing for the data transmission to Eurostat in September 2025. This required development of methods for three tables that had previously not been reported by Sweden.

1.2. Table A1a – Wooded land

Sweden's forest statistics, reported to international processes such as FAO/UNECE and Forest Europe, have traditionally been delivered by the Swedish Forest Agency (SFA), based on five-year averages from the National Forest Inventory (NFI). This creates challenges when aligning with economic accounts, which require annual data for calendar years. Another identified issue is that the categories FAWS (Forests available for wood supply) and FNAWS (Forests not available for wood supply) are not annually geographically explicitly known for Sweden. We see a need for future work in updating the annual official statistics product for Formally protected forest land, voluntary set-asides, consideration patches and unproductive forest land (FFHI) (Statistics Sweden & SFA, 2023), so that it includes an estimate for areas of FNAWS according to the definitions in the forest accounts.

To improve the timeliness of NFI reporting, two methods have been tested:

1. The Five-in-one method aims to provide more up-to-date forest data without increasing field measurements utilizing the full sample every year. The method introduces the need for revision of the preliminary annual estimates when the full sample has been revisited, similar to the LULUCF reporting.
2. Model-assisted estimation, using auxiliary data from Sweden's full coverage national land cover map (NMD 2018) was also evaluated. The estimates showed small improvements, likely due to outdated auxiliary data and maintained panel effect when only one inventory year was utilized in estimation.

An entirely model-based approach is not advised since such estimates will be biased for the true population and its development. Different map data for auxiliary data will be investigated further in collaboration with Statistics Sweden, who maintain such map data for statistical purposes.

1.3. Table A2a – Timber

For timber volumes, Sweden's traditional forest reporting relies on five-year averages from the Swedish NFI. Time lags from the method, compared to expressed intent of the forest accounts, are relatively large, particularly estimates of annual forest growth.

To improve timeliness and accuracy, two methods were evaluated:

1. The Five-in-one method enhances annual estimates by integrating Sentinel-2 satellite imagery and machine learning with NFI data, to impute annual measurement values to the full sample. This approach reconstructs each plot's annual history, allowing for better tracking of growth and harvest events. By combining spectral data with field measurements, the model can predict annual forest dynamics after the inventory year. Upon the fifth year, field measurements are made permitting the evaluation of the model errors. Despite improvements, challenges remain in modelling small-volume felled trees, for which five-year averages are still more reliable.
2. Methods for model-assisted estimation have been tested on annual permanent sample, leveraging auxiliary data from Sweden's national land cover map (NMD 2018) and mapped tree volumes (Skogliga grunddata 2018). While this method slightly reduces year-to-year variation and standard errors in volume estimates, it underperforms compared to standard NFI estimates when applied to per-hectare volume calculations, which are essential for the forest accounts.

In conclusion, the Five-in-one method offers a promising way to improve the timeliness of estimates for the forest accounts while reducing panel effects in estimation. Its effectiveness will be further improved using model-assisted estimation with the full sample by way of combining the Five-in-one method with model-assisted estimation for the totals. For per-hectare estimates the Five-in-one method will be used stand alone. The project advises the use of preliminary estimates in the forest accounts deliveries, which will be gradually updated as more measurements have been performed.

1.4. Table A2b – Monetary timber account

Seven methods for estimating the value of the monetary timber stock and flows in Sweden have been tested. Stumpage value methods, a consumption value method, net present income value methods and a few other methods provide preliminary monetary estimates of the forest available for wood supply (FAWS). The results range from SEK 376 billion to SEK 1 142 billion. It shows that the choice of method, categorisations and assumptions have a crucial effect on the end results. It is therefore important that the comparability over time is maintained through a consistent time series without changes in methodology. Any such changes need to be accompanied by a revision of the time series.

In this report, the methods are evaluated based on data usage, compilation time and the impact of assumptions made. Methods that had more specific assumptions, with a smaller impact on the end results, are preferred to methods with wide ranging assumptions on the macro level. A specific discussion is held on the topic of net income methods and its dependence on a general equilibrium in the economy. The difficulty in choosing the "correct" discounting factor largely affects any outcome.

A recommendation is made to use a consumption valuation method that considers region, assortments and maturity classes both in timber stock and prices. That will utilise a maximum of official statistics, but compilation time is kept at a realistic level given the short time frame between input data availability and reporting deadline.

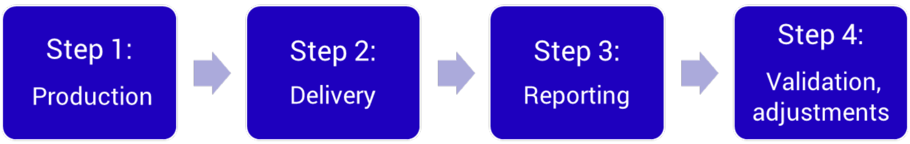
Some tasks remain until the reporting deadline in September 2025:

- Valuation of the timber stock in other wooded land, which is about 9 percent of the timber volume reported.
- Making more robust assumptions on the timber stocks' distribution to assortments after felling.
- Asking for clarification from Eurostat on what adjustments to make on prices used in the valuation, relating to both costs for silviculture and the maturity of the timber stock.
- Fine tunings of the calculations.

1.5. Implementing the results and other preparations for future work

Parallel to the development of methods, the project has been working on a process for the annual delivery of data to the EFA questionnaire. The total process can be divided into four steps, starting with the production of data according to the EFA requirements and the methods that have been developed in this project. The data will then be delivered to Statistics Sweden's environmental accounts, who will report it to Eurostat through the EFA questionnaire. The final step is Eurostat's validation and then the adjustments that Sweden might need to do based on the validation's result

Figure 1.1. Steps in the Swedish production and delivery process of EFA



1.6. Conclusions

By the end of the project, the outcome is improved estimates for all three tables. In conclusion for Table A1a and A2a, estimates using the Five-in-one method shows promise for improving the timeliness of forest statistics but requires continuous monitoring of measurement errors as new observations are collected. Initially we therefore suggest a revision of estimates until full five-year estimate has been inventoried. Model-assisted estimation could be used together with the full Five-in-one dataset in the future, potentially using updated auxiliary data. However, such implementation will take some time to achieve.

The recommendation for Table A2b is to use a consumption valuation method that considers region, assortments and maturity classes both in timber stock and prices.

Since the actual delivery of data to the EFA questionnaire is in September 2025 and this project ended in March 2025, the project cannot present the actual data that will be delivered in September. The result therefore consists of pilot data tables, with figures that will be updated just before the latter delivery. Consequently, there will be some adaption in the methods to better suit the final data. This will be handled outside the scope of this project. Details of remaining tasks are described in the chapter of each table.

The result is also a structure for the annual working process of deliveries to the EFA questionnaire. The project has prepared for the EFA questionnaire transmission and validation, by making a transmission of preliminary data in September 2024.

Besides the improved ability to produce all the tables in the Swedish Forest Accounts, there are several impacts of the project outcome that will improve quality in other statistical areas, where forest statistics is the main data source, or where the improved methods could be used or an inspiration to further development. The project has also improved the cooperation between the three authorities who have participated in the project.

2. Introduction

2.1. Background

This report is the result of a Eurostat grant financed project at Statistics Sweden, with the overall aim to develop more and better data needed to underpin the policies under the European Green Deal (EGD)[1]. The report describes the work within the project's work package *WP1 Development and implementation of forest accounts*. The aim was to set up a production process for the reporting of the Swedish Forest Account, according to the amendment of Regulation 691/2011 on environmental accounts, preparing for the data transmission to Eurostat in September 2025. The work was conducted by Statistics Sweden, the Swedish Forest Agency (SFA) and the Swedish University of Agricultural Sciences (SLU).

In the annual reporting of forest accounts to Eurostat, Sweden has reported data in table B1, since 2008. This table consists mainly of economic indicators derived from National accounts. The amendment of the regulation on Environmental accounts requires further mandatory tables to be reported. These tables include estimates for physical units on forest land area (Table A1a), timber volumes (Table A2a), with both stock and flow variables as well as monetary estimations on timber (Table A2b). Sweden had previously not reported them to Eurostat.

The project was preceded by a Eurostat grant project that created a roadmap for the development and implementation of forest accounts in Sweden. It identified priorities and obstacles that had to be resolved for producing good quality data and a sustainable production process. These issues were further explored within this following project, by improving the models and sources identified in the roadmap. Besides the development of data, the aim was also to practically implement and co-ordinate the Swedish forest accounts to include both physical and monetary tables.

This report describes how the steps in the roadmap were conducted and implemented. The structure of the report follows the tables required in the Eurostat reporting, with a separate description and discussion for each table. SLU has been a driving force in the physical parts of the production of tables A1a and A2a. In the economic production of tables A2b, SFA and Statistics Sweden, in the form of National Accounts and

[1] Project name and acronym: Development of forest and ecosystem accounts, environmental subsidies and material footprints. 2023_SE_EGD.

Environmental Accounts, have collaborated to identify issues and to develop sustainable methods. The result of this work is the implementation of the working process of reporting and validating data of forest accounts in Sweden.

2.2. Objectives and tasks

The general objective was to improve and further develop the Swedish forest accounts, based on the result from the previous project. The main objective was to implement the expanded forest accounts, including estimations on forest land area and timber volumes, with both stock and flow variables as well as monetary estimations on timber. This was specified in two specific objectives:

1. Improving methodologies that have been pinpointed with a need for further investigation, according to the roadmap from the previous project.
2. Setting up priorities and processes for national coordination with concerned authorities, to be able to access data sources, improve data quality, timeliness and investigate national data needs.

Table 2.1. Roadmap for implementing European Forest Accounts at Statistics Sweden

Activity	Description	Table
1. Making estimates from the NFI more timely and accurately	Post-stratification, data for reference year X	A1a
2. Setting up future data delivery system	A plan for future statistical deliveries between the stakeholders	A1a
3. Making estimates from the NFI more timely and accurately	Model assisted estimation and hybrid estimation, data for refence year X	A2a
4. Setting up future data delivery system	A plan for future statistical deliveries between the stakeholders	A2a
5. Making valuation estimates	Bottom-up method, Tax Agency data	A2b
6. Making valuation estimates	Current national accounts method	A2b
7. Making valuation estimates	NPV method, includes a trial of the Heureka system	A2b
8. Setting up future data delivery system	A plan for future statistical deliveries between the stakeholders	A2b
9. Preparation for EFA questionnaire transmission	Setting up validation rules	A1a, A2a, A2b

Source: Statistics Sweden, 2024, A roadmap for implementing Swedish forest accounts. Deliverable 1.1 of Eurostat grant project 2022_SE_EGD

The objectives were achieved with the help of three main tasks:

- T1.1 Improvement and further development of models that were identified in the work with the roadmap.
- T1.2 Implementing the results.
- T1.3 Sending questionnaire and metadata. This included setting up data tables and other preparations prior to transmission of EFA questionnaire and metadata to Eurostat, including preparing validation rules in order to facilitate transmissions.

2.3. Deliverables in project

This report is one of three deliverables of work package 1 in the Eurostat grant financed project *2023_SE_EGD*. The report is supplemented with pilot data tables in an Excel file and a PDF file containing slides for an online workshop presentation on forest accounts, which will be organised by Eurostat later in 2025. Accordingly, all three deliverables in WP1 are:

- D1.1 Report on development and implementation of forest accounts in Sweden
- D1.2 Pilot data tables
- D1.3 Workshop presentation on forest accounts

3. Table A1a – Area of wooded land

Table 3.1. EFA Table A1a – Wooded land, Area of wooded land, in 1000ha

Assets (stocks and flows) Code, Description	Opening area (Dec t-1)	Afforestation and other increases	Deforestation and other decreases	Statistical reclassification (+/-)	Balancing item (+/-)	Closing area (Dec t)
1 Forest						
1.1 Forest available for wood supply						
1.2 Forest not available for wood supply						
2 Other wooded land						
2.1 Of which available for wood supply						
3 Other land with tree cover available for wood supply						

Note: Entries in blue cells (codes 1, 1.1, 1.2, and 2) are mandatory items for reporting. Entries in white cells are voluntary items for reporting.

Source: EFA Questionnaire, Eurostat

3.1. Identified reporting issues

Traditionally, national statistics delivered to international forest processes, like the FAO/UNECE Forest Resources Assessment (FRA) and Forest Europe’s State of Europe’s Forests (SoEF), have been compiled as five years averages from the Swedish NFI. SFA is the national correspondent in this work, which has been conducted in collaboration with the organization responsible for the NFI, i.e. SLU.

The NFI is an area-based sample inventory, which started in 1923, but has been conducted annually since 1953. A design combining permanent and temporary plots was introduced in 1983 (Fridman et al. 2014). State estimates are based on estimates from both permanent and temporary plots, which are weighted together and reported as an estimate with the “middle” year of a five-year-period as the reference year. As an example from the ongoing reporting process for FRA 2025, estimates for the reference year 2020 are thus reported based on data collected in 2018, 2019, 2020, 2021 and 2022. Most measurements, models and statistical reporting from the NFI have been adapted to produce estimates as this type of averages for the full sample, i.e. for five-year periods.

In the currently outlined Forest Accounts table A1a, data are requested for a calendar year with a starting figure for the 1st of January and a closing figure for the 31st of December, as is customary in economic accounts. This poses some challenges regarding forest statistics, which were discussed in the previous grant project report (A roadmap for implementing Swedish forest accounts. Deliverable 1.1 of Eurostat grant project 2022_SE_EGD).

Concerning the category *Forests available for wood supply* (FAWS) and the category *Forests not available for wood supply* (FNAWS), there is currently no geographically explicit information for Sweden according to the delineation defined in the EFA handbook. The different categories are not always distinguishable in the field (i.e. forest owners intention/plan is unknown). However, some areas are geographically explicitly known, and there are official statistics regarding parts of FNAWS (Statistics Sweden & SFA, 2023), we denote these area estimates FFHI (Formal protected forest, Voluntary set-asides, Environmental consideration and Unproductive forest land).

Statistics for the areas of FAWS can only be produced based on certain assumptions. Since the Swedish NFI can estimate the total area of forest and the total area of other wooded land and other land with tree cover, the changes in these areas can be estimated. However, to separate them between FAWS and FNAWS will imply subtracting the total FNAWS (when these become available) from the total area of forest. Thus, both areas will be available for reporting.

3.2. Methods and data sources investigated

In the following section, estimates are produced using an updated NFI estimate. NFI *Five-in-one* data and comparisons are made between those and ordinary five-year estimates and those of model-assisted estimates. These different estimators and the data used will be described in the following sections. The field data from the Swedish NFI were described in the previous report and such descriptions will therefore not be included in this report, other than in the results, the comparisons, and for the purpose of describing the other methods investigated as a part of this project. Then these alternatives are discussed for the estimation of areas in table A1a.

Table 3.2. Table A1a using five-year averages for area estimates (t-1 => data from 2018-2022, t => data from 2019-2023). 1 000 ha.

Assets (stocks and flows) Code, Description	Opening area (Dec t-1)	Afforestation and other increases	Deforestation and other decreases	Statistical reclassification (+/-)	Balancing item (+/-)	Closing area (Dec t)
1 Forest	27 872	67	86	81	27 934	27 872
1.1 Forest available for wood supply						
1.2 Forest not available for wood supply						
2 Other wooded land	2313	109	89	-60	2 273	2313
2.1 Of which available for wood supply	0	0	0	0	0	0
3 Other land with tree cover available for wood supply	527	13	17	-3	520	527

Source: Table structure: EFA Questionnaire, Eurostat. Data: SLU

3.2.1 Five-in-one

This project aims to improve the timeliness of NFI estimates without the need for additional field measurements. To monitor changes in wooded areas, Sentinel-2 Level-2A imagery available in Google Earth Engine were applied to each NFI plot. A machine learning model was evaluated to classify plots to the different categories requested by the Forest Accounts. A machine learning model was trained using both the previous NFI plot category class and the spectral values (initial and changed) from Sentinel-2 to predict the current category class. The model achieved an accuracy of approximately 97 percent. However, this high accuracy is somewhat misleading, as 99.1 percent of these forest's categories remain unchanged, highlighting that, given the characteristics of these specific forest categories, Sentinel-2 data alone may not be sufficient to accurately classify these subtle changes.

SLU therefore propose an estimate based on field-measurements using inventory data for full sample, where SLU assumes increasing measurement errors over time. Estimates have been produced (Table 3.3) and these can be compared to five-year average data (Table 3.2). Assumptions can be evaluated, and estimates updated, ensuring that the estimates represent the population of interest.

In table 3.2, estimates are given using NFI-data from five years of inventory, i.e. the most timely/up-to-date estimate that can currently be produced (February 2025) using the standard procedure as five-year averages, i.e. the procedure used in previous reporting to FRA and SoEF and in-line with other official statistics for Sweden. Because estimates including the field-data from 2024 will be published as National Official Statistics at the NFI website at the end of May 2025 it cannot be published elsewhere before this date due to Swedish legislation (the Official Statistics Act). Since this implies that the normal reporting reference year will lead to delays vis-à-vis the requirements of the Forest Accounts Five-in-one estimates have been produced (table 3.3) and in the following sections these are described in the following section and then compared to other estimates.

Table 3.3. Table A1a using Five-in-one data for area estimates (t-1 => data for 2022, t => data from 2023). 1 000 ha.

Assets (stocks and flows) Code, Description	Opening area (Dec t-1)	Afforestation and other increases	Deforestation and other decreases	Statistical reclassification (+/-)	Balancing item (+/-)	Closing area (Dec t)
1 Forest	27 923	66	82		-17	27 890
1.1 Forest available for wood supply						
1.2 Forest not available for wood supply						
2 Other wooded land	2 278	81	98		-12	2 283
2.1 Of which available for wood supply						
3 Other land with tree cover available for wood supply	519	13	17		7	522

Source: Table structure: EFA Questionnaire, Eurostat. Data: SLU

Estimator and variance estimation to evaluate Five-in-one estimates

If we assume all tracts from the total five-year sample S_0 was inventoried during a single year, the ratio estimator used in the Swedish NFI could be expressed as (disregarding the strata):

$$\hat{\tau}_y = \frac{\sum_{i \in S_0} y_i}{\sum_{i \in S_0} a_i} A,$$

with variance estimator

$$\hat{V}(\hat{\tau}_y) = K \left(\frac{A}{\sum_{i \in S_0} a_i} \right)^2 s_q^2,$$

where $K = |S_0|$, A is the size of the frame, y_i is the variable of interest y measured as the total at tract $i \in S_0$, a_i is the total area of tract a_i inside the frame, and

$$s_q^2 = \frac{1}{K-1} \sum_K (y_i - \bar{y})^2,$$

where

$$q_i = y_i - a_i \frac{\sum_{i \in S_0} y_i}{\sum_{i \in S_0} a_i}.$$

For the Five-in-one project, we assume that $S_1 \subset S_0$ is measured with a zero-expectation error ϵ_i with variance σ_i^2. Thus, the estimator becomes

$$\hat{\tau} = \hat{\tau}_y + \hat{\tau}_{\epsilon_1},$$

where

$$\hat{\tau}_{\epsilon_1} = \frac{\sum_{i \in S_1} \epsilon_{1,i}}{\sum_{i \in S_1} a_i} A.$$

Under the assumption of independent measurement errors, the variance can be estimated by

$$\hat{V}(\hat{\tau}) = \hat{V}(\hat{\tau}_y) + \hat{V}(\hat{\tau}_{\epsilon_1}),$$

where

$$\hat{V}(\hat{\tau}_{\epsilon_1}) = M \left(\frac{A}{\sum_{i \in S_1} a_i} \right)^2 s_p^2,$$

$M = |S_1|$, and

$$s_p^2 = \frac{1}{M-1} \sum_M (p_i - \bar{p})^2,$$

with

$$p_i = \sigma_i^2 - a_i \frac{\sum_{i \in S_1} \sigma_i^2}{\sum_{i \in S_1} a_i}.$$

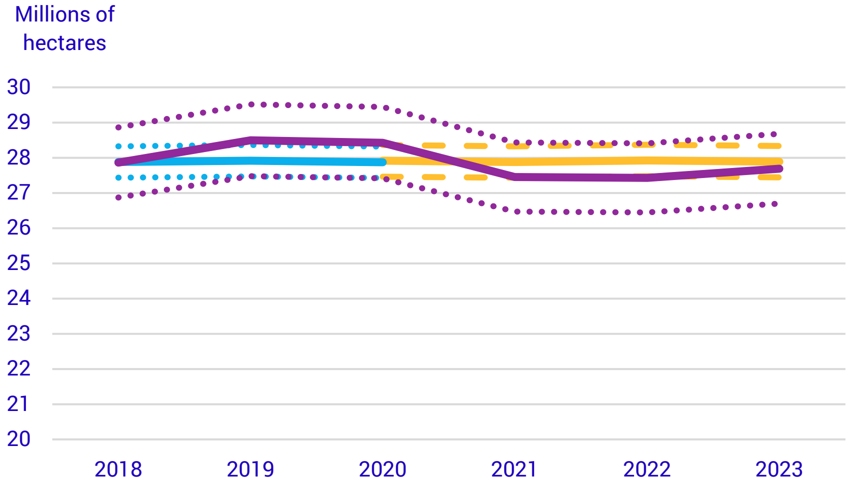
As the variance of the measurement errors are not available, these must be substituted for estimated variances. Under the reasonable assumption that the variance of the measurement errors is increasing with time, an upper bound of this variance can be found by evaluating the measurement errors when revisiting the plots, i.e. after the full five-year rotation.

Results from Five-in-one estimation

The different estimates described above are shown in a time-series of estimates for comparison (figure 3.1, 3.2 and 3.3) for the different totals, with differing lengths depending on estimator.

Figure 3.1. Estimated total forest area (FNAWS+FAWS), with approximate 95% confidence intervals for Sweden

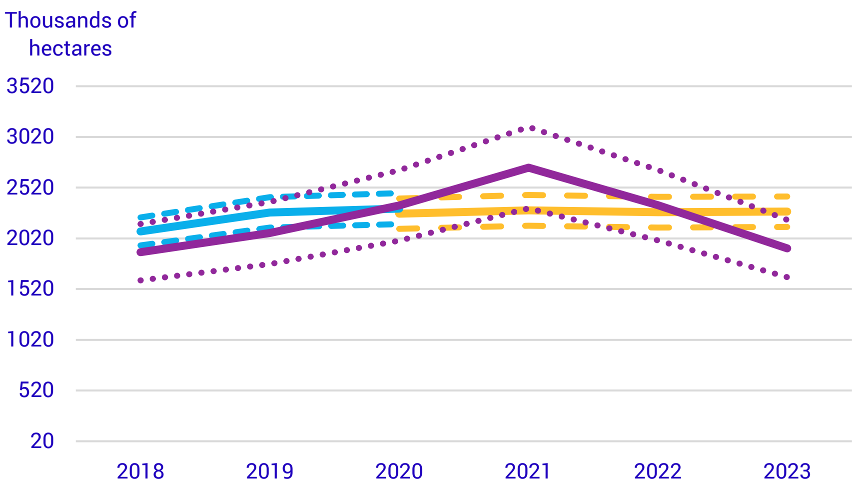
In purple annual estimate with field inventory subset only, in blue NFI five-year averages and in yellow a Five-in-one estimate.



Source: SLU

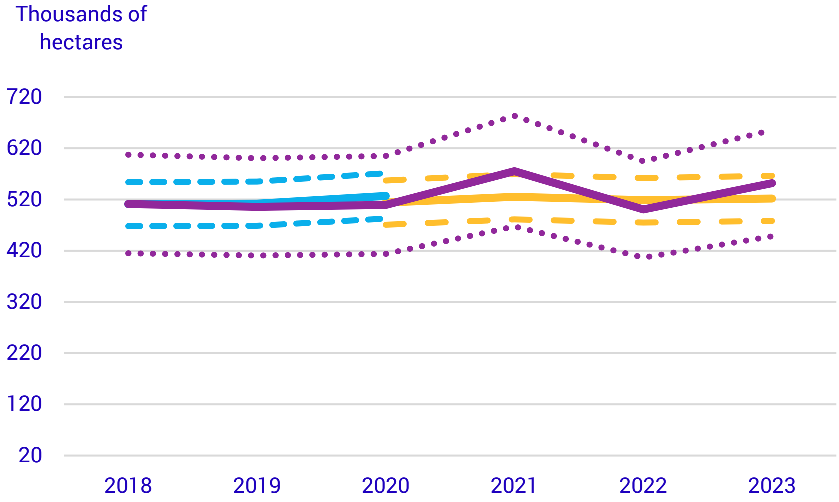
Figure 3.2. Estimated area of total wooded land, with approximate 95% confidence intervals for Sweden

In purple annual estimate with field inventory subset only, in blue NFI five-year averages and in yellow a Five-in-one estimate.



Source: SLU

Figure 3.3. Estimated area of other land with tree cover, with approximate 95% confidence intervals for Sweden
In purple annual estimate with field inventory subset only, in blue NFI five-year averages and in yellow a Five-in-one estimate.



Source: SLU

Figures 3.1-3.3 illustrate preliminary findings that the linear trend stabilizes the estimates as the yearly panel effect is reduced. Evaluations of error contributions from our assumptions will be performed and annually assessed as new data are collected on permanent sample. This is one of the projects that is currently underway, and which will keep evolving together with Five-in-one project to improve Sweden's LULUCF reporting. SLU suggests using these preliminary statistics for years which consequently will be updated as measurements are completed, i.e. statistics for reporting year *t* will be reported *t+2* and finalized at *t+3* for the estimated areas.

3.2.2 Model assisted estimation

To obtain timely information using one inventory year only, SLU explored model-assisted estimation (utilizing available wall-to-wall auxiliary information and models, within design-based inference). This is the same as what was indicated in the plan, i.e. post-stratified estimation with categorical data is in essence model-assisted estimation (e.g. Särndal et. al. 1992). The national land cover map produced by the Swedish Environmental Protection Agency (EPA) from 2018 was used[2]. It contains data for the whole of Sweden partitioning it into classes of productive, unproductive and non-forest land, which should fit the needs for this project. In addition, modelled living tree volume per

[2] NMD 2018 downloaded on link: https://geodatakatalogen.naturvardsverket.se/geonetwork/srv/swe/catalog.search#/metadata/8853721d-a466-4c01-afcc-9eae57b17b39

hectare per pixel data were used[3]. The older map versions were chosen since they have data fully covering Sweden.

These two large rasters were then divided into smaller subsets based on the NFI's statistical strata delineated by polygons. This was achieved through geoprocessing techniques that clipped the raster to each stratum. The resulting rasters were trimmed to decrease extent to the masked area, reprojected and the two datasets were aligned. For NMD pixels classified as productive and improductive forest, with volumes from the other raster layer were resampled to it, using r terra's resample function with method *near* (Hijmans, 2025). This process was repeated for each of the NFI strata (regions). The same data was used for both area and volume – but for the sake of area estimation it is the same thing as post-stratified estimation using the NMD-class forest (unproductive + productive forest). This will be verified in later analysis.

The estimators used, follow standard model-assisted survey sampling approaches (Särndal et. al. 1992, Gregoire & Valentine, 2008, Andersen et al 2024) with ratio type estimators to account for the differences in tract size within the frame. The estimators are presented in the following sections.

Stratum-Level Total Estimator

For each NFI stratum h, SLU estimated the total forested area $\widehat{FA}_h$ pertaining to forest land according to FAO definitions and where NFI data are used together with NMD-data.

Estimator for total forested area per stratum:

$$\widehat{FA}_h = \sum_{j=1}^{N_h} \hat{a}^*_{\text{forest},j} + A_h \frac{\sum_{i=1}^{n_h}\left(a_{\text{forest},i} - \hat{a}_{\text{forest},i}\right)}{\sum_{i=1}^{n_h} a_i}$$

where $\sum_{j=1}^{N_h} \hat{a}^*_{\text{forest},j}$ is the total area of forest according to helpdata for the stratum as the sum over raster pixel areas in NMD classes "productive forest" and "unproductive forest", and $a_{\text{forest},i}$ is the area in forest in tract i according to field measurements for plots added for the tract, and $\hat{a}_{\text{forest},i}$ is the area of the tract i which is in forest according to the NMD help data and a_i is the total area of the inventoried tract i.

Variance estimators for the per stratum total

The variance estimators for total volume and total area:

Variance of the total volume estimator per stratum is estimated as:

[3] Downloaded on link: https://www.skogsstyrelsen.se/sjalvservice/karttjanster/skogliga-grunddata/

$$\hat{V}(\hat{\tau}_h) = \hat{V}\left(\sum_{j=1}^{N_h} \hat{a}^*_{forest,j} + A_h \frac{\sum_{i=1}^{n_h}(a_{forest,i} - \hat{a}_{forest,i})}{\sum_{i=1}^{n_h} a_i}\right)$$
$$= \frac{A_h^2}{\left(\sum_{i=1}^{n_h} a_i\right)^2} \hat{V}\left(\sum_{i=1}^{n_h}(a_{forest,i} - \hat{a}_{forest,i}) - \widehat{R_h}\sum_{i=1}^{n_h} a_i\right)$$
$$\approx \frac{A_h^2}{\left(\sum_{i=1}^{n_h} a_i\right)^2} n_h \cdot \hat{V}\left(\hat{a}_{\text{forest},i,h}\right)$$

where:

$$\hat{a}_{\text{forest},i,h} = a_{\text{forest},i} - \hat{a}_{\text{forest},i}$$

Overall estimate of totals for Sweden and variance estimation across strata

Total area is estimated as the sum over estimates from independent strata, the variances are also added (independence).

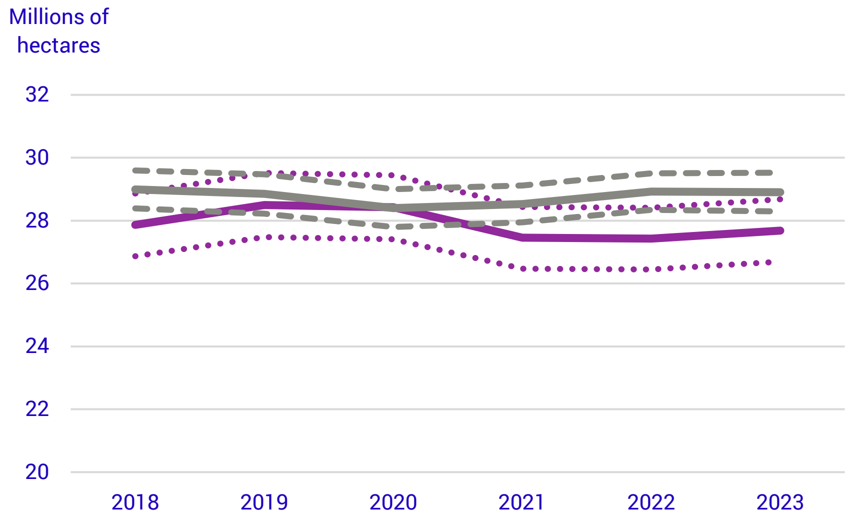
$$\widehat{FA} = \sum_h \widehat{FA}_h$$

Since inventory is performed on independent samples across strata, the estimated variances from each stratum are added for the total estimated variance of the estimator.

$$\hat{V}(\widehat{FA}) = \sum_h \hat{V}(\widehat{FA}_h)$$

Figure 3.4. Estimated total forest area

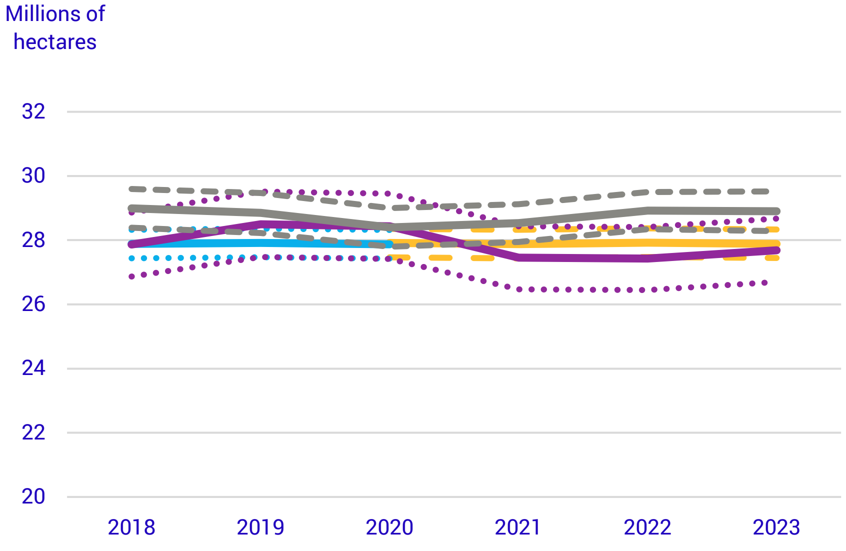
Using one year of NFI permanent plot data and model assisted estimation (grey) and ordinary one-year estimate from NFI in purple. Dotted lines correspond to estimated approximate 95% confidence intervals for the true total each year.



Source: SLU

Figure 3.5. Estimated total forest area, with approximate 95% confidence intervals for Sweden

In purple annual estimate with field inventory subset only, in blue NFI five-year averages, in yellow a Five-in-one estimate and in grey model assisted estimates using permanent sample only.



Source: SLU

In figure 3.5 we see that either our attempt at model assisted estimation has not worked properly (i.e. coding errors) or there seems to be an adjustment to the estimates when applying help-data in estimation, which may indicate that the sample for the permanent plots could have a non-optimal placement in the realized sample in comparison to the auxiliary data available today. Perhaps this may imply that model-assisted estimation (Särndal et. al. 1992) would provide important improvements in estimates and should be investigated further in NFI statistics production. Initial investigations should include updated auxiliary data and comparisons with the temporary sample. The temporal misalignment of the auxiliary data used, since it was published in 2018 using remote-sensing data captured during a long time period preceding that publishing year could also have led to potential increases in standard errors in comparison to updated auxiliary data. Another aspect which will need investigating is the geoprocessing methods used in this project.

These results will be evaluated during 2025 and compared with the estimates from the temporary sample as well as those from model-assisted estimation with updated auxiliary data sources and both field-inventoried samples.

Overall homework for all parties is to agree on the area of FNAWS, where all parties of the FFHI-statistics production should be involved to avoid inconsistencies and SFA should retain final decision.

4. Table A2a – Timber

Table 4.1. EFA Table A2a – Timber on Wooded land, Volume of timber stocks, in 1000m3 over bark

Assets (stocks and flows) Code, Description	Opening stock (Dec t-1)	Net increment	Removals	Irretrie-vable losses	Statistical reclassific-ation (+/-)	Balancing item (+/-)	Closing stock (Dec t)
1 Forest							
1.1 Forest available for wood supply							
1.2 Forest not available for wood supply							
2 Other wooded land							
2.1 Of which available for wood supply							
3 Other land with tree cover available for wood supply							

Note: Entries in blue cells (codes 1, 1.1, 1.2, and 2) are mandatory items for reporting. Entries in white cells are voluntary items for reporting. Net increment, irretrievable losses, statistical reclassification and balancing items are grouped and required as other changes (between opening and closing stocks) in the Regulation for forest not available for wood supply and other wooded land.

Source: EFA Questionnaire, Eurostat

4.1. Identified reporting issues

Similar to Table A1a, the traditional way of producing estimates for Table A2a consists of five-year-averages from the NFI. However, especially for some values in this table, e.g., annual harvested volume and annual forest growth, using data from the NFI gives even longer time lags in estimates. All issues identified in the previous report have not been addressed specifically, but important steps have been investigated, which will guide us in our next steps of implementation.

4.2. Methods and data sources investigated

The following section describes estimates that are produced using NFI data from the full five-year sample, one-year sample and the Five-in-one project. Alternative data sources have been used in model-assisted estimation and the results discussed for the estimation of volumes in table A2a.

4.2.1 Five-in-one project

This work seeks to enhance timeliness in NFI estimates without additional field-measurements, similar to what was described for the area estimates in previous section. For volumes, different methods have been investigated to ensure that estimates better reflect conditions for a single year. While temporary plots are not currently included, future implementations could incorporate them, using the same methodology as those used for permanent plots.

The NFI measures individual tree attributes, including diameter and status (new trees (ingrowth), harvested or dead (natural mortality)) on each plot. This enables the reconstruction of each plot's annual history. The tree data is summed to plot-level volume, basal area, and stem density per hectare. Additionally, the dataset includes elevation, latitude, land type (productive forest, wet land, water etc.), stand factors such as vegetation type for the ground, and field layers.

In order to detect events such as harvests and, to some extent, natural losses, Sentinel-2 Level-2A imagery in Google Earth Engine was used.

1. The Scene Classification Layer (a special band within the satellite image) filters out unwanted pixels, including clouds, shadows, snow, and defective areas.
2. Extraction of key spectral bands, including Blue (B2), Green (B3), Red (B4), Near-Infrared (B8), and Shortwave Infrared (B11, B12).
3. By merging multiple satellite images captured throughout the growing season, composite spectral band values are generated for each plot, reducing the issue with outliers.

Combining augmented annual NFI data with Sentinel-2 imagery through machine learning provides a robust method for predicting both growth and harvest yields. Table 4.2 details the structuring of training data, including features and targets. The model learns by adjusting its weights to minimize the difference between predictions and actual outcomes. In this manner, annual models forecast outcomes one to four years ahead, thus completing the five-year permanent plot sample.

Table 4.2. The training data comprises examples (rows) from plots along with spectral values that span a starting year to an ending year.

Features (start year)	Features (end year)	Targets (end year)
Spectral values	Spectral values	Stock volume
Basal area		Harvested volume (during period)
Stem density per ha		
Land type		
Elevation		
Latitude		
Stand factors		

Source: SLU

The annual estimates rely on a hybrid approach that merges direct observations with imputed model predictions. For observations, the analytical estimates are used to estimate both volume and variance, while each prediction model is handled via a bootstrap procedure to obtain an empirical mean and variance. Once these two sets of estimates are available, an inverse-variance weighting step combines them. This final step ensures that each source, observations and predictions, contributes in proportion of its relative precision, resulting in a hybrid estimate.

While models and auxiliary data sources, such as Sentinel-2, are useful for generating annual estimates, there are specific cases where these kinds of models are not yet appropriate. For example, trees that have been felled but remain within the forest are typically small in volume and difficult to model reliably, as well as mortality and ingrowth. Similarly smaller trees have not yet been incorporated in the modelling step. These will be handled through similar assumptions as in the LULUCF-reporting initially and prioritized for model development and evaluation with other development projects in the coming years.

Table 4.3. EFA Table A2a using five years of data for opening stock and balancing item, one year of data for removals and increment (t-1 => data from 2018, 2019, 2020, 2021, 2022), (Removals => data from 2021), (Increment => data from 2023). 1000 m3 over bark.

Assets (stocks and flows) Code, Description	Opening stock (Dec t-1)	Net increment	Removals	Irretrie-vable losses	Statistical reclassific-ation (+/-)	Balancing item (+/-)	Closing stock (Dec t)
1 Forest	3 720 515	100 977	84 339	1409		-10 532	3 726 621
1.1 Forest available for wood supply							
1.2 Forest not available for wood supply							
2 Other wooded land	20 324	308	45	0		298	20 885
2.1 Of which available for wood supply							
3 Other land with tree cover available for wood supply	19 276	1390	521	0		-204	19 940

Source: Table structure: EFA Questionnaire, Eurostat. Data: SLU

In Table 4.3 (Table A2a) data that have been sent to Eurostat with descriptions with regards to calculations are included. Earlier SLU have described the different time lags for NFI estimates of removals and growth (increment) estimates.

4.2.2 Model-assisted estimation

To obtain timely information SLU explored model-assisted estimation (utilizing available wall-to-wall auxiliary information and models, within design-based inference). The national land cover map produced by the Swedish EPA from 2018 was used since it contains data for the whole of Sweden partitioning it into classes of productive, unproductive and non-forest land which should fit our needs for the project[4]. In

[4] NMD 2018 downloaded on link: https://geodatakatalogen.naturvardsverket.se/geonetwork/srv/swe/catalog.search#/metadata/8853721d-a466-4c01-afcc-9eae57b17b39

addition, modelled living tree volume per hectare per pixel data were downloaded[5]. The older versions were chosen since they have data fully covering Sweden.

These two large rasters were then divided into smaller subsets based on the NFI's statistical strata delineated by polygons. This was achieved through geoprocessing techniques that clipped the raster to each stratum. The resulting rasters were trimmed to decrease extent to the masked area, reprojected and aligned. For NMD pixels classified as productive and unproductive forest with volumes from the other raster layer were resampled to it using r terra's resample function with method *near* (Hijmans, 2025). This process was repeated for each of the NFI strata (regions).

The estimators used, follow standard model-assisted survey sampling approaches (Gregoire & Valentine, 2008, Andersen et al 2024) with a ratio type estimators to account for the differences in tract size. The estimators are presented in the following sections.

Stratum-level total estimators
For each NFI stratum h, we estimate:
- The total volume $\hat{\tau}_h$,
- The total forested area $\widehat{FA}_h$. These estimates are based on trees with $dbh > 99\ mm$ and forest land according to FAO definitions.

Total Volume Estimator per Stratum:

$$\hat{\tau}_h = \sum_{j=1}^{N_h} \hat{y}_j^* + A_h \frac{\sum_{i=1}^{n_h}(y_i - \hat{y}_i)}{\sum_{i=1}^{n_h} a_i}$$

Where

$$\sum_{j=1}^{N_h} \hat{y}_j^*$$

is the total volume in forest in the strata h according to our help data (i.e. sum over pixel values multiplied by pixel area in hectares). A_h is the total area of the stratum frame, y_i is the sum of the volumes in tract i of n_h tracts in the stratum, and corresponding volumes for the tract in predicted volumes from our help data is $\hat{y}_i$.

Variance estimators for the total estimators
The variance estimators for total volume and total area:

[5] Downloaded on link: https://www.skogsstyrelsen.se/sjalvservice/karttjanster/skogliga-grunddata

Variance of the Total Volume Estimate

$$\hat{V}(\hat{\tau}_h) = \hat{V}\left(\sum_{j=1}^{N_h} \hat{y}_j^* + A_h \frac{\sum_{i=1}^{n_h}(y_i - \hat{y}_i)}{\sum_{i=1}^{n_h} a_i}\right)$$
$$= \frac{A_h^2}{\left(\sum_{i=1}^{n_h} a_i\right)^2} \hat{V}\left(\sum_{i=1}^{n_h}(y_i - \hat{y}_i) - \widehat{R_h} \sum_{i=1}^{n_h} a_i\right)$$
$$\approx \frac{A_h^2}{\left(\sum_{i=1}^{n_h} a_i\right)^2} n_h \cdot \hat{V}(\hat{q}_{i,h})$$

where the residual term is:

$$\hat{q}_{i,h} = (y_i - \hat{y}_i) - \hat{R}_h a_i, \quad \text{with} \quad \hat{R}_h = \frac{\sum_{i=1}^{n_h}(y_i - \hat{y}_i)}{\sum_{i=1}^{n_h} a_i}$$

Overall estimate of totals for Sweden and variance estimation across strata

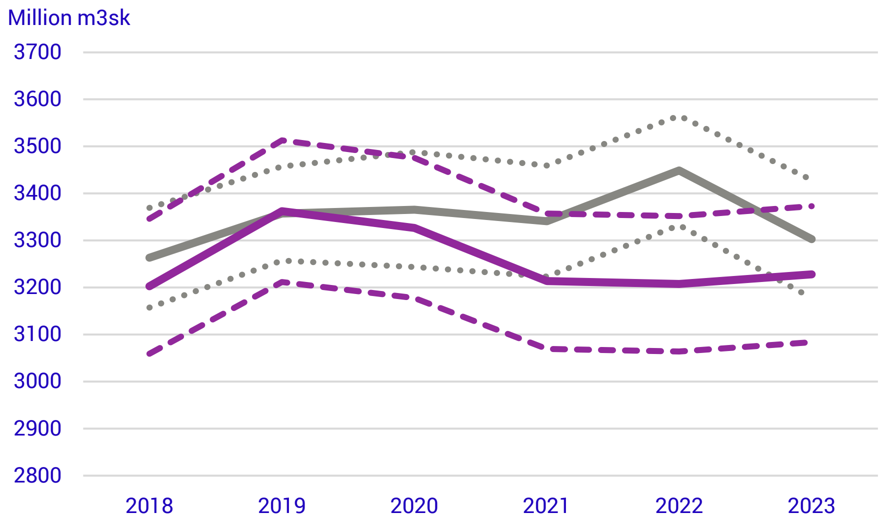
Total area is estimated as the sum over estimates from independent strata, the variances are also added (independence).

$$\hat{\tau} = \sum_h \hat{\tau}_h$$

$$\widehat{FA} = \sum_h \widehat{FA}_h$$

Figure 4.1. Estimated total volume for trees with dbh>99 mm

Using one year of NFI permanent plot data for model assisted estimation in grey, and NFI one-year estimates in purple. Error bars correspond to approximate 95% confidence intervals for the true total each year.



Source: SLU

The need for per hectare values
Since some of the FNAWS is unknown in a geographically explicit way, we need to estimate volumes per hectare to estimate the part of the total volume that belongs to that category and subtract those estimates for the total geographically non-explicit FAWS. This is done using the statistics from FFHI for the total areas and then estimating volume per hectare estimates for each subset. This, in turn, makes the robustness of the per hectare estimator important to the overall accuracy of the forest accounts.

For model-assisted estimation following the above sections, the overall per-hectare estimate can be made as model assisted ratio-of-ratios estimator (c.f. Anderssen et al 2024):

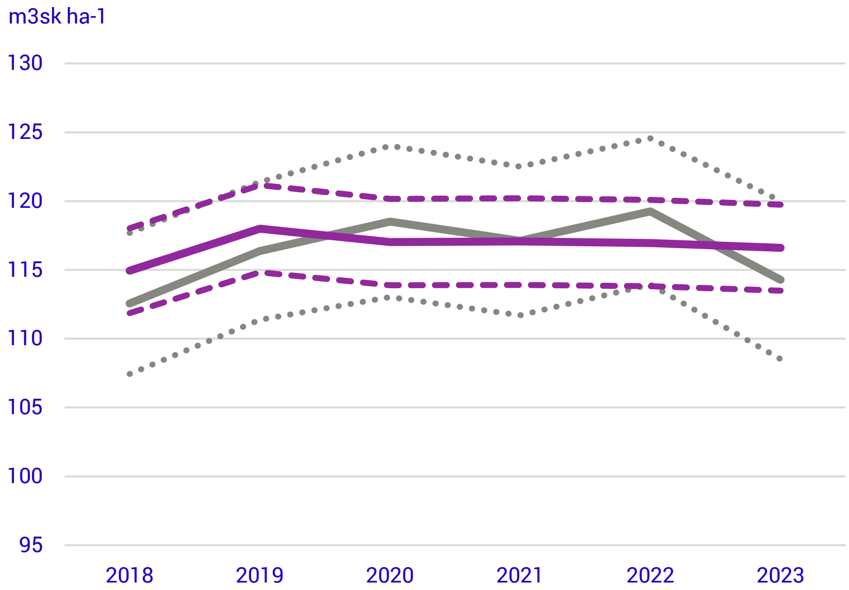
$$\hat{R} = \frac{\sum_h \hat{\tau}_h}{\sum_h \widehat{FA}_h}$$

Applying the approximate variance estimator (e.g. p 154, Cochran, 1977):

$$\hat{V}(\hat{\mu}) \approx \frac{1}{\left(\sum_h \widehat{FA}_h\right)^2} \sum_h \left[\hat{V}(\hat{\tau}_h) + \hat{R}^2 \hat{V}\left(\widehat{FA}_h\right) - 2\hat{R}\widehat{\mathrm{Cov}}\left(\hat{\tau}_h, \widehat{FA}_h\right)\right]$$

Results from model-assisted estimation and standard NFI estimates (according to Fridman et al 2014) are visualized in figure 4.2.

Figure 4.2. Estimated volumes per hectare for trees with dbh>99 mm in Swedish forests
Using one year of NFI permanent plot data and model assisted estimation in grey, and one-year-estimates using ordinary NFI estimates in purple. Error bars correspond to estimated 95% confidence intervals for the true value each year.



Source: SLU

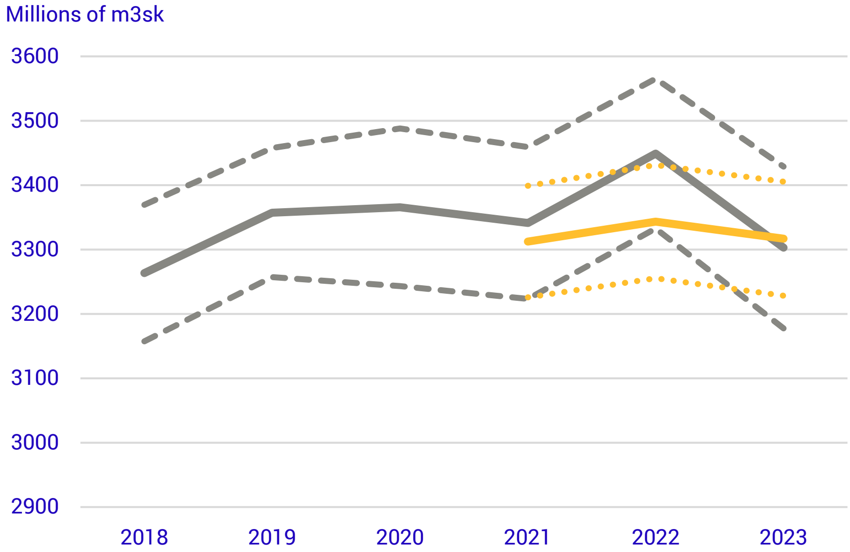
While model-assisted estimation performs slightly better with between-year-variation for both total area and total volume estimates, these differences are not very large. However, when comparing model-assisted estimation for both volume and area to estimate the volume per hectare, as is the objective for the forest accounts for some important domains, this estimator underperforms in comparison to NFI stand-alone estimates. The reason for SLU's interest in averages is because spatially explicit information for many of the domains that constitute FNAWS are unavailable. This implies that the best available area information needs to be coupled with the best available per hectare estimate and then subtracted from the best available estimate for the total volume.

Comparisons of Five-in-one synthetic estimates and model-assisted estimates for volume

We have now visualized most of the different estimates, but for volumes we have not visualized the Five-in-one estimates with those of our model assisted for volume.

Figure 4.3. Estimated total volume (for trees with dbh > 99 mm) on forest land (FAWS+FNAWS)

With one panel model assisted estimates in grey and Five-in-one estimates in yellow.



Source: SLU

There is a panel effect in using one panel of the NFI permanent sample, which is visible in the MAS estimation, but this is evened out in Five-in-one estimates. In addition, combining the two (full panel estimation with different assumptions and models for imputation/measurements, Five-in-one together with model-assisted estimators using auxiliary data) seems like a good option to obtain better annual estimates for the total volume and area.

5. Table A2b – Monetary timber account

Table 5.1. EFA Table A2b – Timber on Wooded land, Monetary value of timber stock, in million national currency

Assets (stocks and flows) Code, Description	Opening stock (Dec t-1)	Net increment	Removals	Irretrievable losses	Revaluation (+/-)	Statistical reclassification (+/-)	Balancing item (+/-)	Closing stock (Dec t)
1 Forest								
1.1 Forest available for wood supply								
1.2 Forest not available for wood supply								
2 Other wooded land								
2.1 Of which available for wood supply								
3 Other land with tree cover available for wood supply								

Note: Entries in blue cells (codes 1, 1.1, 1.2, and 2) are mandatory items for reporting. Entries in white cells are voluntary items for reporting. Net increment, irretrievable losses, statistical reclassification and balancing items are grouped and required as other changes (between opening and closing stocks) in the Regulation for forest not available for wood supply and other wooded land.

Source: EFA Questionnaire, Eurostat

5.1. Introduction

This chapter contains a section on monetary valuation of flow variables, a section on stock variables and lastly some conclusions. The flow variables in the monetary timber account; net increment, removals etc. are generally valued according to similar methods regardless of what choices are made for the valuation of the stock variables (opening and closing stocks), while the stock variables have a range of different methods that can be applied. Therefore, the flow variables are presented firstly and the stock variables afterward. The section on stock variables is subcategorised by the different methods that have been explored during this grant project.

The basis for almost all valuations in this chapter is calculations combining volumes and prices. Timber volumes from the NFI and annual felling's statistics given in the EFA timber volume table (chapter 4 in this report), and prices from official roundwood price statistics and energy price statistics.

The EFA reporting table on monetary timber stock includes different points in time. There is opening stock (t-1), changes during the year (t) and closing stock at end of the year (t), the latter will equal the opening stock in the next reporting. Roundwood price statistics is published quarterly and annually, energy prices annually. To estimate end-of-year prices (ultimo prices), an average price of the fourth quarter and first quarter of the following year is calculated. These prices are then used for both opening and closing stocks with one year in between them. Flow variables are valued at annual average prices. For the annual energy prices, t-1 prices are used at opening stock and t prices for the closing stock, the flow variables are priced by an average of t-1 and t prices.

The pilot year t, that is most commonly used in this chapter, is year 2020. At the time of writing, it was the most recent midyear of the NFI five-year averages.

NFI volume estimations are commonly over bark, whereas the trading volume (and therefore the roundwood price statistics) in Sweden is under bark. A conversion is therefore needed to combine them. At roadside, the roundwood contains bark but the bark itself is not priced and sold until downstream at the industry. No separate value is given to the bark as it is a residual product that is already included in the transaction at the roadside.

5.2. Flow variables

The valuation of flow variables does not differ much between valuation methods. They are therefore briefly presented in this initial section and are generally valid regardless of method chosen to valuate the opening and closing stocks. Since flow variables are the main interest in compiling GDP, the last subsection is devoted to the current method used in the Swedish national accounts.

5.2.1 Net increment and removals

The monetary values in net increment and removals are based on prices year t and volumes given in the timber account of the annual EFA reporting (previously described in chapter 4). The volume of net increment is assumed to be distributed across subcategories like tree type or region as is the opening stock, which is further described in section 5.3 Stock variables.

Annual statistics on removals are already available by assortment, which simplifies the valuation substantially. These statistics do not include branches and tops, which need to be added separately using energy statistics on the production of wood chips from tops and branches. The corresponding price statistics is not by roadside, but rather at the industry. Prices need to be adjusted for the cost of transportation, and the cost of the wood chipping to be aligned with other prices used in the calculations, as well as the EFA handbook.

5.2.2 Revaluation, balancing item and other flows

The reporting table includes a column on revaluation which is meant to specifically record changes in prices. Revaluation has been calculated using the average of the opening and closing stocks, multiplied with the difference in ultimo prices in the opening and closing stocks.

Since there are no volumes to be valuated in the categories *Irretrievable losses* and *Statistical reclassification*, for the pilot year 2020, there has not been any specific development of methods for these flow variables. The balancing item is simply used as a residual flow that is the result of the differences between opening and closing stocks after all the other flows have been added or removed.

5.2.3 A note on current method used in the Swedish National Accounts for flow variables

The National Accounts (NA) compiles information on a variety of products and economic aggregates related to the forestry and logging activity, as represented in the EFA table B1. The main interest for the NA is value added of each economic activity. In the Swedish NA, forests outside formally protected areas are in general regarded as cultivated. The timber growth is regarded as being produced continuously over the entire period from the setting of plants to the final felling of mature trees. Growing trees are recorded as inventories of work-in-progress. Information on the stock of timber in the Swedish NA is found in the section 5.2.5 on valuation of stocks in the national accounts.

Logging is a separate activity that adds value to the mature trees when they are harvested and put into other economic uses. The felling of trees reduces the inventory of standing timber, and this volume and other reductions are subsequently subtracted from gross growth of timber. Only the net growth of standing timber impact GDP and is added to the inventory. Data on gross growth and natural reductions are provided by the Swedish NFI and statistics on felling's from SFA.

The value of net growth is derived by using estimated stumpage prices on the aggregate level without differentiating between tree species and regions. The stumpage price takes its departure from the sales prices of different assortments and subtracts the logging costs, all recorded in cubic metres under bark and then transformed with an appropriate coefficient to correspond with the stumpage price in cubic metres over bark including treetops.

It should be noted that when information of own costs is used in the estimation, these need to be adjusted for the difference in historic and actual replacement costs of machinery included in depreciation (consumption of fixed assets). This regards for example the capitalised cost method in section 5.3.5. When the forest owner pays for the logging service it is assumed that the price paid to the enterprise undertaking logging, like other market prices, includes a margin that also covers for the actual replacement costs.

Regarding the table A2b on monetary timber accounts, the Swedish NA does not compile the detailed and complete information related to the rows and columns in the table. Forest available for wood supply in NA includes voluntary protected areas, but these protected areas are included in *Forest not available for wood supply* in table A2b. Net increments and removals are not included separately in the NA values, only the net growth excl. felling's is recorded. Even though the volume measures can be separately valued, the distinction between protected area and forest available for wood supply still differs in relation to table A2b.

The stumpage price currently used in the Swedish NA is an average for the entire Swedish economic area. The average is constructed out of information on sales prices for the two main uses, sawlogs and pulpwood weighted together with their annual shares. The information is taken from the annual statistics on the felling of trees by assortment. As is shown, in the subsection below (*Stumpage value at the aggregate level of the economy*), the stumpage price currently used in NA differs from the best practise that will be implemented in table A2b of the forest accounts.

Stumpage pricing is not frequent any more in Sweden. The statistics on stumpage prices was terminated in 2003 due to quality issues. Therefore, estimated stumpage prices are used. These estimated prices are derived from output prices by assortment, excluding the logging costs. How these prices are derived is explained in more detail under the relevant subsections dealing with stumpage prices and valuation.

The annual average stumpage price used for year 2020 in the NA is currently 219.9 SEK per cubic meter over bark including the top. Since only sales prices for sawlogs and pulpwood are used to calculate the stumpage price and the other uses are priced lower, there is an obvious risk that the stumpage price is overestimated in NA.

Stumpage value at the aggregate level of the economy
The valuation of flow variables, such as timber growth and felling, is related to the final use of the timber. The main uses are sawlogs, pulpwood, and energy purposes. Additionally, some parts, notably the tops and branches, are left in the forest to dry and are later processed into woodchips.

The stumpage price is derived by excluding the average costs of felling and transport in the forest to the pick-up place from the average sales price. The average sales price is measured in relation to the volume under bark. Therefore, the sales price is transformed by a coefficient that relates the volume of timber over bark to the sales volume under bark. This price is used for the valuation of the inventory and changes in the inventory. The price corresponds to the volume including bark, treetops and losses caused by the logging activity.

The average total stumpage price used in this report in relation to the price currently used in NA, also considers the use of pulpwood differentiated between coniferous and broadleaf trees, as well as uses of timber as fuelwood and woodchips. These uses of timber are valued lower and, when integrated in the formula, consequently, makes the stumpage price lower.

Table 5.2. The impact of differences in the aggregate stumpage price formula used in this report in relation to the Swedish NA

Differences in the aggregate stumpage price formula	Percentage change (%)
More differentiated assortment	-4.9
Logging costs (-)	-5.2
Relation over bark/under bark	+3.5
Combined impact on price	-6.6

Source: Statistics Sweden, SFA

The data on logging costs has also been revised. In this case it is an upward revision also making the stumpage price lower. Another improvement is the use of an up-to-date relation between the volume measurement units used for sales prices (under bark) and the inventory of standing timber (over bark including the top). By these small changes the total stumpage price will better reflect the actual value of the harvested volume of timber put into economic use.

The stumpage price currently used in the NA relates to the average price of the year and is only used for net increment. In a complete forest balance, there is also a need for a stumpage price related to the beginning and end of the year, used for the valuation of the entire inventory.

The average stumpage price for year 2020 is estimated to 205.4 SEK per cubic meter over bark incl. the top. The revised stumpage price is 6.6 percentage lower than the current in use. In table 5.2, the impact of the improvements of the price formula is summarised.

Both the method used for net growth in the NA and the revised method used in this report corresponds to the principle of using the average stumpage price that is unadjusted for the impact of younger trees included in felling’s. These trees are removed trough thinning of the trees in the location to give more space for the remaining trees to grow properly. The stumpage price thus represents a weighted average of mature and younger trees.

5.3. Stock variables

The monetary valuation of the opening and closing timber stocks can be valued using several different methods according to the EFA handbook. The main methods are the stumpage value, the consumption value and net income value method (also called net present value method). These same three main methods are the subsections below. In total seven different methods have been tested and they are categorised by the mentioned main theoretical method used. The methods themselves will not be theoretically described in this report for that is given in the EFA handbook and other Environmental and National accounts guidelines. The focus here is on presenting results and describing the calculations for Sweden. There is also a section on other methods that are not in the EFA handbook.

Throughout this section there are three methods for the aggregate valuation of the inventory. The aggregate stumpage value method provides a link to the method currently used in the national accounts. By aggregate valuation should be understood that an aggregate stumpage price is used for the valuation of the entire inventory (stock of work in progress). In two of the aggregate methods, we also consider the distribution of age in the inventory.

The final subsection deals with the principles of stock valuation in the national accounts. At the end of this chapter there is a section on conclusions and a comparison of the different methods.

5.3.1 Stumpage value methods

The stumpage value method is the most direct method, requiring the least amount of data. It is currently used by National accounts in Sweden to value the net growth and felling's. According to a survey among reporting countries in the EFA handbook, it is the most used method in the reporting of the monetary timber stock table.

In the stumpage value method, the current average stumpage price is used in combination with the current volume of the timber stock. When this method is applied, it is recommended to differentiate between different species. The reason pointed out in the EFA handbook is that prices vary by species.

In the Swedish context there is also a variation in stumpage prices by region. In the northern parts of Sweden, the average distance between the standing timber and the pickup places at forest roads as well as to the end users is longer. This increases the logging and transportation costs and thus lowers the value of standing timber in relation to the use. This is reflected in the sales prices.

The stumpage value method uses information on average stumpage prices related to the entire inventory of timber. Since younger trees are rarely cut down, stumpage prices for a large part of the inventory are missing. The average price used in this report is the estimated average stumpage price of trees cut down and sold. The total volume of felling's, according to data on large scale forestry, include about 20-30 percent of trees that are cut down due to thinning measures. These trees are younger than mature trees and represent a substantially lower stumpage price since their sales prices are lower and their logging costs twice as high as for mature trees. This makes the average price of felling's closer to the desired average price for the entire inventory, but the issue is how close it will get.

5.3.2 Stumpage value at the aggregate level of the economy

The same stumpage price formula is used for stocks and flow with the main difference being the time of valuation. Stock values relate to the price level at the beginning/end of the year and flow values to the average prices of the year. To derive at stumpage prices the estimated average annual costs of logging is subtracted from the sales prices (cf. table 5.3 below). For the different stumpage prices used for valuation of the inventory in this report, the price level at the end/beginning of the year is represented by the unweighted average of the prices for the surrounding quarters. At the best, stumpage prices for the inventory should also be differentiated in relation to the age of the trees.

The current method is simplified since it only uses the information of actual final use of timber by assortment cut down in the same year as the net growth is accounted for. A future improvement would be to use an average over several years, at least for the inventory, preferably over an entire business cycle. The average length of the business cycles might not be easy to establish. An approximation would be a 10-year moving average. A moving average has the advantage that it gradually incorporates changes in the assortment and therefore is more stable than annual figures.

Table 5.3. Average prices at the beginning of 2020 and average annual production costs in forestry, SEK per cubic metre over bark incl. treetops

Measures and revenue	Prices and costs
Costs in forestry (+)	96.3
Operating surplus (+)	120.0
Stumpage price (=)	216.3
Logging (+)	115.1
Sales price (=)	331.4

Source: SFA and FRIS

It should be noted that the stumpage price shown in table 5.3 is only used at the aggregate level. Disaggregated stumpage prices by assortment and species might give a different result when used to value the inventory. Still the method behind the stumpage prices, used in this report, is the same. On the aggregate level, the value of the inventory of standing timber (opening balance of year 2020) and estimated by this method, is approximately 635 billion SEK (cf. table 5.12). This figure is derived by multiplying the timber volume of approximately 2,937 million cubic metres with the stumpage price 216.3 SEK.

The EFA handbook refers to average stumpage prices (EFA(2024) § 4.75). The stumpage price of actual felling's is a price that represents

70-80 percent mature trees and 20-30 percent younger trees but on average the age is probably higher than the weighted average age of trees in the entire inventory. The conclusion is that when the average stumpage price of actual felling is used, the value of the inventory will be overestimated.

The interpretation of the result for the aggregate stumpage value method is that the estimated stumpage price represents the stumpage price that on average will reflect the value of the current timber volume, if it in the future will be included in the same proportions of fellings as the current volume of fellings. This means that there is no rate of return in future period to be added to the current value of trees in the inventory, until they become cut down. The only addition to their values is holding gains/-losses due to price changes of sold timber and changes in the logging costs.

Detailed stumpage value method

Timber prices and the timber stock vary depending on location, wood product etc. By creating a valuation method that takes this into account, the overall quality of the valuation will increase. As will the complexity and compilation time of the calculations.

Table 5.4. Example of the stumpage valuation method.

		Timber volumes (V)	Stumpage prices (P)	Stumpage method value (V*P=)
Region 1	Assortment 1	V_{11}	P_{11}	M_{11}
	Assortment 2	V_{12}	P_{12}	M_{12}
	…			
Region 2	Assortment 1	V_{21}	P_{21}	M_{21}
	Assortment 2	V_{21}	P_{21}	M_{21}
…	…			

Source: Statistics Sweden, SFA

The number of factors that can be included in the valuation is limited by what is provided through the underlying estimations in the official statistics, which are the categorisations that are available from price statistics and timber volume statistics. In Sweden the price statistics is categorized by four regions and five wood product assortments. The timber stock statistics from the NFI has a wide range of categorisations, 21 regions, tree types, diameter classes and more. The only common categorisation between the two forms of statistics is by the four larger regions and tree type (the latter is tree type per certain assortments in the price statistics). A simplified example of the calculations of the detailed stumpage value is seen in the above table 5.4. Below is a table showing official price statistics by region and assortment for 2020.

Table 5.5. Roundwood price statistics (SEK/m^3) by region and assortment in Sweden, 2020.

	Northern Norrland	Southern Norrland	Svealand	Götaland	Total Sweden
Sawlogs of Scots pine	452	448	439	538	473
Sawlogs of Norway spruce	402	439	403	555	489
Sawlogs Total	*437*	*443*	*417*	*551*	*483*
Pulpwood of conifers	334	276	249	332	303
Pulpwood of Norway spruce	336	288	260	322	301
Pulpwood of birch	272	266	260	347	305
Pulpwood Total	*323*	*279*	*257*	*327*	*302*

Source: Statistics Sweden, SFA

Bridging assortment and timber stock

One of the key obstacles to valuating the timber stock lies in combining price statistics, which is estimated by assortment, with timber stock statistics where the assortment is unknown. The NFI field measurements cannot predict what the future assortments will be after felling.

One option is to simply disregard this problem and assume an average price, not considering assortments and regions. This would then not utilise what is given through the categorisations within the available statistics and therefore lower the quality of the valuation.

In this project, the possibility of using similar assumptions as in the Heureka system (described in section below *Net Income Methods*), to bridge the gap between timber stock and assortment, was investigated. However, that model is more adaptive and based on individual trees. There was no possibility to extract any clear reusable assumptions from it.

The project also initiated correspondence with Skogforsk, the Forest research institute of Sweden. By using their access to data from forest harvesting machines, a series of conversion functions might be constructed specifically targeting the challenges of this valuation. This needed separate financing and therefore was outside the scope of this grant project, but should be kept in consideration for future development work within Sweden's EFA reporting.

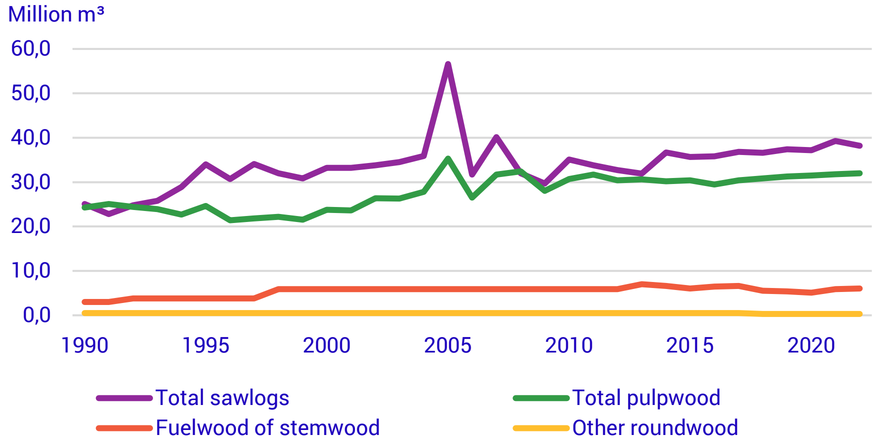
Section 4.72 of the EFA handbook provides an example of how to solve this problem using assumptions based on previous fellings:

> *"Depending on the data source, roadside pick-up prices may not be available following the same classes as for the data on the volume of timber.*
>
> …

As a result, where roadside pick-up prices need to be used for valuation of the stock because stumpage prices are not available, it will be necessary to use assumptions about the links between assortments and the expected patterns of future fellings and uses. For example, a long term (e.g. 15 year) average of assortments might be assumed as the way in which the current timber stock will be used in the future."

During this project, there was only time to form an average for one year, by which the felling was distributed to region and assortment tree type. The assumption is then made that the timber stock will become the same assortments as this generalisation of fellings. After this grant project is completed, work will continue to form a longer average from the felling statistics, hopefully 10 or 15 years, even though there usually is no large variation over time in terms of what assortments come from the annual fellings. The percentage of sawlog volume out of total removals has been between 46 and 50 percent annually since 2010, for pulpwood it has been between 41 and 44 percent. The rest is fuelwood and other wood assortments.

Figure 5.1. Timeseries of the main felling assortments in Sweden, solid volume excluding bark



Source: Statistics Sweden, SFA

FAWS distribution

The by far most dominant part of the EFA reporting table on monetary timber stock is the forest available for wood supply (FAWS). The timber volume of FAWS, using NFI data, is the preset from which the valuation is made. But while general timber stock statistics from the NFI can be subcategorised by region, tree type etc. FAWS cannot. The reason behind this is that some of the forest land not available for wood supply (FNAWS) has an unknown location and is only known as a total for the entire country. In order to subcategorise the FAWS estimations to region and tree type, it is assumed that it shares the same distribution as the overall timber stock (excluding formally protected forests and unproductive forests, which are known and can be subtracted from the overall stock).

Stumpage price estimation
There are no statistics in Sweden on stumpage prices, but there is statistics on prices by the roadside, where the forest owners themselves have felled and transported the roundwood to roadside, as seen in table 5.5. This contract type is relatively small in terms of market share in Sweden, but it is the one that most closely related to what is described in the EFA handbook. Otherwise most roundwood sales in Sweden are felling agreements/contracts. By taking roadside prices and deducting the cost of felling and transportation to roadside, available from the official forestry cost statistics, an estimated stumpage price per cubic meter can be calculated according to the EFA handbook.

However, it is not completely clear from the handbook if, and in that case when, to take costs for silviculture into consideration. A further clarification on when to use stumpage price and resource rent in terms of cultivated forests is needed, specifically clear instructions in terms of what valuation method is chosen.

For the provisional calculations made in this project, the estimated stumpage price described above and roadside prices unless harvesting costs has been used. Therefore, silvicultural costs are not considered at this moment, but this might change after further clarification from Eurostat and possible revisions of the handbook. An example of the estimated stumpage prices, used in the calculations in this project, is shown in table 5.6.

Table 5.6. Estimated stumpage prices (SEK/m^3) under bark for the most common assortments, per region, year 2020.

Region	Assortment	Annual average price
Northern Norrland	Sawlog	289
	Pulpwood (coniferous)	187
	Pulpwood (leafed)	124
Southern Norrland	Sawlog	305
	Pulpwood (coniferous)	144
	Pulpwood (leafed)	128
Svealand	Sawlog	288
	Pulpwood (coniferous)	129
	Pulpwood (leafed)	131
Götaland	Sawlog	420
	Pulpwood (coniferous)	194
	Pulpwood (leafed)	216

Source: Statistics Sweden, SFA

Fuel wood prices
Besides the more common roundwood assortments of sawlogs and pulp wood, the felling statistics also includes the assortment fuelwood and other roundwood. These volumes currently do not have a corresponding price in the roundwood price statistics. Instead, energy price statistics on wood fuel is used. These prices are downstream, at industry rather than at roadside, so a further reduction with the use of forestry cost statistics is made. There is currently no specific price available for the assortment other roundwood, but it is under development in the roundwood price statistics. In the meantime, the fuelwood price is believed to be the closest related price, the volume of other roundwood is relatively small so it should not have a large impact on the valuation.

Fuelwood is priced in the unit SEK/MWH while round wood price statistics is in SEK/m^3 under bark. A conversion is therefore required.

Results
Making all the above adjustments and then calculating the different prices multiplied by the quantities, as in the example in table 5.4, a pilot monetary timber stock table for FAWS can be compiled. The result is presented in the table 5.7. At the time of writing this report, the most recent 5-year average from the NFI has the mid-year of 2020, subsequently prices and costs from 2020 have been used.

Table 5.7. Preliminary EFA reporting table A2b using a detailed stumpage value method. Year 2020, million SEK.

	Opening stock	Net increment	Removals	Revaluation	Balancing Item	Closing stock
FAWS	649 820	19 911	-19 142	-40 823	531	610 297

Source: Statistics Sweden, SFA

5.3.3 Consumption value method
The consumption value method requires more data than the stumpage value method. It differentiates parts of the timber stock, mainly by age or diameter class, to be more accurate in prices and volumes.

For clarification, stumpage prices are not only used for stumpage valuation methods, but also in other methods according to the EFA handbook.

Valuing only timber that is mature for felling
In the previous method, with a mixture of stumpage and consumption value methods, no special importance was given to the age of the trees. A cubic meter of roundwood from 20-year-old pines was valued at the same price as a cubic meter of 100-year-old pines. This is unrealistic, as the older trees will more likely have a greater diameter class and more likely to be used as sawlogs than younger trees. Another factor is in terms of accounting, where younger forests have silvicultural costs that forests mature for felling have not. Both points suggest that it is

sensible to use a price that is differentiated based on the age or maturity of the trees.

The NFI produces estimations on maturity classes. These classes range from bare forest land to young forest and beyond, all the way to old forests that are mature for final felling.

The estimated stumpage prices can be further adjusted to be more in line with the different maturity classes. This can be done in a variety of different ways. It can be assumed that trees below a certain maturity class will only become fuel or pulpwood. Prices might be reduced by what assumptions of future silvicultural costs they might generate. The EFA handbook is still a bit unclear what is the preferred approach to these price adjustments or if there should be any adjustments at all. Further clarification is needed to provide guidance and increase comparability between national estimations in the EFA reporting.

An interesting example and possible extreme, is to assume that trees that are below the minimal final felling age does not have any value. One reasoning behind this is that any felling done before thinning or final felling (i.e. clearing) is only done for the reason to maximise the value of the standing timber, at the time of future final felling, since there is no cost coverage for early fellings. This might not be completely in line with national accounting standards, but it does provide a good point of comparison with other methods, as it should be the lowest value given the range of different adjustments that can be made on the stumpage price for lower maturity classes.

For the example in this method, besides valuating the volume of trees that are mature for final felling, it is assumed that 30 percent of the volume in the thinning maturity classes are also valued, but only by pulpwood prices. In 2020, pulpwood and fuelwood prices were fairly close. These presets and assumptions result in the monetary values presented in table 5.8 below. The flow variables are the same as in the detailed stumpage value method.

Table 5.8. Valuation of only timber mature for felling. Year 2020, SEK million.

	Opening stock	Closing stock
FAWS	440 537	410 640

Source: Statistics Sweden, SFA

5.3.4 Net income methods

This method is also called the net present value method. The timber stock is divided into age classes, and assumptions are made regarding the future harvest year. These future flows are then discounted to the reporting year, using assumptions about a discounting rate, price and cost development over time etc. The discount rate used in this report is 2 percent. This follows from global discussions on the need to use a common discount rate for international comparability in the national accounts (OECD2025, §170). The EFA handbook is more flexible on this issue and recognises the need to apply a discount rate relevant in relation to the domestic forestry activity.

The aggregated net income method

The stumpage price related to mature trees in the net income method, is the same as in the aggregate stumpage price method (cf. table 5.6 above). The sales prices also include trees cut down for thinning. These trees have a lower sales price per volume and, in relation to mature trees sales from thinning, have a downward impact on the average sales price of actual felling's. The stumpage price that corresponds to the actual harvested volume of timber therefore relates to an age of harvested trees that is lower than the stumpage price of mature trees. The stumpage price applied here corresponds to the estimated price of all trees cut down. If this method is used for table A2b, there is a need to adjust the stumpage price for the difference in the average age of mature trees cut down and the actual trees cut down (including thinning and other forestry measures).

Once the stumpage price is estimated and the length of the production period is set, this method is rather straightforward to apply. The length of the production period (100 years) is equal to the estimated average age of trees in the statistics on annual final felling's, taken from the Swedish NFI. In table 5.9 below, the discounted stumpage prices at the beginning of the year are shown.

Table 5.9. Value of the forest inventory at the beginning of 2020 by discounting the stumpage price

Age of trees, years	Discount factor (%)	Timber volume m^3	Discount stumpage price SEK	Value in million SEK
0-2	0.14	16 130	30.8	496
3-10	0.16	23 236	33.6	781
11-20	0.19	62 049	40.2	2 493
21-30	0.23	164 939	49.0	8 079
31-40	0.28	311 213	59.7	18 582
41-60	0.37	760 189	80.4	61 090
61-80	0.55	556 713	119.4	66 479
81-100	0.82	191 872	177.4	34 046
101-	1.00	850 638	216.3	183 993
All trees		2 936 978		376 039

Note: the real discount factor used is 2 percent according to international recommendations related to the update of the System of National Accounts (SNA2025) (OECD (2025), §170).

Source: Statistics Sweden, SFA

The total value is SEK 376 billion. This is slightly less than 60 percent of the value unadjusted for age difference in the stumpage price, SEK 635 billion.

Net present value method using the Heureka system

The Heureka system is an empirical forestry scenario analyses model that has already been developed and is extensively used in Sweden. It was developed by SLU to facilitate the use of multiple sets of models in conjunction to enable the planning of individual stands, forest holdings or for the evaluation of national scenarios and to enable communication and planning for multiple use cases (Lämås, et al. 2023, Wikström, et al. 2011). These software products are maintained by SLU in broad collaboration with Swedish authorities and stakeholders (SLU, 2024). The software Heureka RegWise is a tool to perform long-term national or regional forest scenario analysis (e.g. Bergqvist, et al 2022). If these scenarios are run for very long time periods an approximate net present value can be calculated based on selected parameters (eg. interest rate, harvesting level and price lists, etc).

About every seventh year, SFA and SLU produce a 100-year scenario analysis of Swedish forests using the Heureka system. The prognosis is based on several pre-defined scenarios and published under the name "Skogliga konsekvensanalyser" (SFA, 2022). Most recently this scenario analysis used the base year 2018 and one of the scenarios is a continuation of the current forestry standards combined with potential harvest (equal to the net growth on forest available for wood supply), as a baseline. There are many possible settings in the Heureka system, so to keep the timeframe of this grant project, the settings from the current forestry scenario were used.

Since the base year was 2018 in the scenario, it is not completely comparable to the previous methods in this report, where 2020 is the reference year. However, to make it somewhat more comparable to the other methods, the same estimated stumpage prices were used, excepting fuel wood, tops and branches where the model had a separate valuation.

Results

The results from Heureka give a net present value of the Swedish forestry. As this was done as a pilot, to simply study the possibility of using the Heureka system in this way, no special care was given to alter the calculations to discern between opening and closing stock. No special valuation of the annual flows for 2022 was made either. However, these current flows would be valued using the same methods as any stumpage or consumption value method, because they are not future flows.

The discounting rate was set to two percent based on the 10-year government bond rate at the time of the writing of this report. The same two precent was also in use at the Swedish National Accounts as the real interest rate. Both sources are preferred methods for deciding the discounting rate according to the EFA handbook.

The resulting net present value of the timber stock in 2022, but estimated stumpage prices from 2020, was SEK 1,142 billion.

A sensitivity analysis was also conducted using the discounting rate of one percent and another using three percent. This sensitivity analysis was made earlier in the project, using prices from 2022. There was no time to rerun the sensitivity analysis with the 2020 prices, so the absolute numbers are not comparable to the result mentioned above. Nevertheless, they are still interesting because of their relation to the two percent baseline scenario. The test using one percent discounting rate gave a timber stock net present value that was 80 percent higher than the baseline. The test using three percent gave a value that was 31 percent lower than the baseline. This shows that the discounting rate has a substantial impact on the end results in present value calculations.

5.3.5 Other valuation methods

The two methods in this subsection are based on data or methods that are not mentioned in the EFA handbook but are still interesting points of comparison.

The capitalised aggregated production cost method

The basic assumption behind this method is that operating surplus is created in proportion to the accumulated costs each year, including the distributed part of operating surplus (compound interest). The project has labelled this method *the capitalised cost method*. The capitalisation factor (rate of return) is chosen to make the sum of costs together with operating surplus per cubic metre equal the stumpage price (cf. table 5.3). By this method we derive an aggregate rate of return that can be compared with the discount rate used in the corresponding net income method.

The capitalised cost method uses information on the production costs and the estimated operating surplus per cubic metre of timber. According to data from the Swedish Forestry Research Institute, approximately half of the costs are related to silvicultural measures in table 5.3 above. This part of costs is distributed according to when soil scarification, planting and thinning are undertaken. The following tentative assumption have been made: At the beginning soil scarification and plantation takes place (40 percent of costs) and after 40 and 60 years on average, thinning is undertaken (5 percent of costs at each time). The remaining costs (50 percent) are related to administrative costs, cost of road infrastructure etc. These costs are distributed with equal shares over the entire 100 years of cultivated growth.

The assumed distribution of costs will be updated with information from SFA to represent more accurate averages for Sweden. Nevertheless, the results are not very sensitive to the underlying assumptions made, except for the average length of the production cycle. The length of the production period is the same (100 years) as in the aggregate net income method and taken from the Swedish NFI.

The costs and the distribution of operating surplus collectively determine the output price for different age classes. These are grouped together to form unweighted average stumpage prices by age class (cf. table 5.3 above). This method is not described in the EFA handbook, but the project argues that it is the closest we can get the principles of the national accounts, without having statistics on actual stumpage prices for every age class.

Operating surplus, to be distributed, accounts for the difference between the stumpage price (216.3 SEK/m^3) and all costs in forestry (96.3 SEK/m^3) which equals 120 SEK/m^3. In the capitalised cost method, operating surplus is distributed for each year in relation to the accumulated production costs including the part of operating surplus capitalised for previous periods of the production cycle of 100 years.

Table 5.10. Stumpage prices (SEK/m^3) and the value of the forest inventory (in million SEK) at the beginning of 2020.

Age of trees	Capitalised costs (1.1%)	Discounted (1.45%)
0-2	39.9	52.2
3-10	45.5	55.7
11-20	54.7	63.4
21-30	66.0	73.3
31-40	79.6	84.7
41-60	106.4	105.1
61-80	147.6	140.3
81-100	181.1	187.2
101-	216.3	216.3
Value of all trees	422 459	422 448

Note: The timber volume is the same as in table 5.9. The discount rate used in the net income method (column discounted) has been adjusted to align the total values of the inventory with the result in capitalised cost method. The stumpage prices thus generated are shown in the right-hand side column.

Source: Statistics Sweden, SFA

Capitalisation is done by adjusting the capitalisation factor (rate of return) so that the sum of capitalisation over the production cycle matches the total operating surplus of 120 SEK/m^3. The capitalisation factor that makes these two values equal in magnitude on the aggregate level for opening balance in 2020, is a rate of 1.1 percent.

The table also includes an adjusted discount rate that approximately gives the same value for the inventory in the aggregated income method as in the accumulated cost case. To achieve this, we need to reduce the discount rate from 2 to 1.45 percent. The table also shows the corresponding discounted stumpage prices.

The bottom-up method with tax reports

Forest owners in Sweden have their properties assessed by the Tax Agency every third year. In between years are assessed by simplified procedures. In the property tax declaration, the forest owner is required to estimate the current timber volume on the property. This volume is then the basis for a "forestry value" that is calculated for all properties with productive forest land that is not formally protected. The forestry value is a part of the larger property taxation value, which besides the forestry value also includes the land taxation value. Besides a forestry value, there can exist other types of values like pasture, buildings etc. The total of all these categories is the property taxation value. That is meant to be 75 percent of the property's market value two years before the assessment year.

The forestry value is partly based on each property's timber stock, area of productive forest land, and site productivity, but also a mean reference value that is specific to the local conditions derived by recent sales of properties nearby. In these property tax assessments that are made every third year, it has been noted by the Swedish Tax Agency that the properties timber stock has not been updated as it should have been. For example it should be reduced after felling, storms etc. (Swedish Tax Agency). A joint project between the Tax Agency, SFA, SLU, and the Land Survey sought to overcome this issue using data from the NFI, laser scanning and other sources. This resulted in the Tax Agency being able to preprint an estimation of the timber stock per property in the latest assessment, regarding the year 2023.

This forestry value could be used as a very approximate value of the timber and forest land. It is interesting because it is a different source of data than the official statistics otherwise used in these valuations (although after 2023 estimations based on NFI data and other sources are used). It is also aggregated from the property level all the way up to national estimation, which makes it a bottom-up method rather than top down. It is an interesting point of comparison to other valuation methods.

Table 5.11. Summary of taxation registry data, 2014 – 2024

Year	Forestry value (SEK million)	Estimated forest area (1000 ha)	Estimated Volume (1000 m3)
2024	959 872	22 013	3 298 720
2023	968 138	22 043	3 339 857
2022	784 975	22 207	3 188 344
2021	787 178	22 365	3 202 208
2020	789 740	22 391	3 216 068
2019	674 367	22 175	3 008 770
2018	676 350	22 366	3 023 408
2017	677 547	22 324	3 031 899
2016	701 622	22 824	2 964 809
2015	703 828	22 877	2 973 875
2014	707 596	22 688	3 013 131

Source: Statistics Sweden, SFA

The data in the table 5.11 is based on productive forest land without felling restrictions (not formally protected forests). The forest area and timber volume above is somewhat higher than the estimations for FAWS using NFI data, indicating the tax registry is overestimated. The overestimation is possibly due to property owners' faulty reporting in the tax assessment, as well as the inability to perfectly recreate FAWS, which also does not include voluntary set-asides, for example.

The complex nature of the calculation of the forestry value and not using the stumpage price, as preferred in the EFA-reporting, makes it less likely for it to be of use in the EFA-reporting. Broad assumptions would also be needed to go from a taxation value to monetary timber account stock estimation. Another issue is the periodical inconsistency. These assessments are only made every third year. The laser scanning used as a key input data takes seven years to scan the entire country. In the data from the Tax Agency there is no scanning-date variable per property that could be used to evaluate the timeliness of the pre-printed timber volume estimation. Also, as can be seen in the table 5.11, every third year, estimations jump as a new assessment is made. Further assumptions would be needed to adjust for this and arrive at a comparable time series. A more fitting use for this data might be as auxiliary data, possibly used when regionalising estimations that cannot be further disaggregated without auxiliary data.

5.3.6 Valuation of the inventory of timber in the NA

In the Swedish NA, the value of the inventory is currently included in the broader value of the entire forest real estates. There is no separate estimate of the inventory of timber in forest available for wood supply. The information in table A2b will in this respect be useful for improvements of the Swedish NA.

The valuation of work-in-progress in the national accounts (NA), is in general oriented towards a share of final output (Eurostat (2014), §3.151 (b) and (c)). At each stage of the growth of timber or for each age or size class, the appropriate share of the final output value should be applied. The final output value depends to a large extent on which use (assortment), saw logs, pulp wood etc., the timber will be devoted to. In the case of work-in-progress of timber, the output value is estimated prior to the logging activities. This corresponds to the stumpage value of standing trees.

The price of a cubic meter of timber volume in a young tree is lower than the price of the same volume from a mature tree. From the user's perspective, the reason is that mature trees, to a greater extent, can be used as sawlogs with less waste, compared to younger trees. Consequently, they have a higher market value. From the production perspective the accumulated production costs is the lower limit to the price that producers are willing to accept. A higher amount of accumulated production costs therefore translates into a higher price per unit of volume. The price also depends on the market situation, including the impact of the business and cycles where buyers compete over the available supply and producers wants to make profit.

Producers have an advantage since they can decide when the timber will be logged and sold. Producers have costs they want to capitalise. In other words, compound interest on the investments is reflected in the price. In this report, the project has compared three different methods for the aggregate valuation of the inventory of standing timber. The stumpage value method, the net income method and the capitalised cost method.

The output value is divided into a volume component and a corresponding price. In NA, the prices used should reflect the actual current cost of acquiring the standing timber volume. Current cost valuation means that this price is regardless of when the timber will be harvested. It is a valuation of the actual timber volume in the current period. The price will in normal market circumstances cover the production costs and contribute to net operating surplus.

5.4. Conclusions on monetary timber account methods

A variety of different methods for estimating the monetary timber stock and flows have been presented in this chapter. In the table 5.12 a summary of the resulting stock values is shown.

Table 5.12. Summary table of valuation method results, millions SEK

Method	Method in detail	Opening stock 2020	Comment
Stumpage value method	Aggregate level	635 268	
	Detailed stumpage value method	649 820	
Consumption value method	Only valuing timber mature for felling	440 537	
Net income value method	Aggregate level	376 039	
	Heureka system	1 142 412	year 2022
Other methods	Capitalised aggregate production cost	422 459	
	Tax assessment data	789 740	

Source: Statistics Sweden, SFA

The valuation methods provide results ranging from SEK 376 billion to SEK 1,142 billion. There are some clusters in the valuation results. Three methods are in the lower spectrum between SEK 350 to 450 billion and two methods are just below SEK 650 billion.

The choice of method, categorisations and assumptions have a large impact on the end results. Whichever method is chosen, it is of great importance that the comparability over time is maintained through a consistent time series. Any change in method during the annual reporting to Eurostat, will need to be accompanied by a revision of previous reporting in the time series. It is probable that some revisions will be needed every reporting year, due to underlying revisions of timber volumes, averages in assumptions etc.

Regarding assumptions, it is noteworthy to observe on what level the assumptions lie in the different methods. Assumptions should preferably only be used where data availability is too low, meaning that assumptions are best put into use in residual areas of the calculations that have less impact on the end results. This is somewhat more accurate for methods that use more data and categorisations, such as the consumption value method and parts of the net income methods. However, the net income methods are accompanied by very broad assumptions about the discounting rate. Also, the Tax assessment method with its forestry value being part of a larger real estate taxation value, that is supposed to equal 75 percent of the market value t-2 years. That is another example of how assumptions need to be made at the macro level to adjust for this and therefore affect estimations greatly.

The greatest variation in estimated monetary value lies with the net income methods. While these are not comparable, as mentioned in the subsection on Heureka, some things are still worth noting. The prices used in the Heureka system calculations are on average lower than in other methods, but the end timber stock value is higher. Because the Heureka-system requires much more time to be fully understood, it is not yet known why these estimates are so high.

Regarding the aggregated estimates, in a sense they can also be compared by the capitalisation factor and discount factor used. In the stumpage value method, no discounting is used which translates into a discount factor equal to zero. That there is no difference between the prices on different age or size classes of trees is unrealistic and that leaves us with the other two methods.

First, it should be noted that under the same assumptions that motivates the use of discounting, the discount factor and the capitalisation factor used to capitalise costs, theoretically is the same, when the value of the inventory is equal. In our case there is a difference between the capitalisation factor (1.1 percent) and the corresponding discount factor (1.45 percent). One reason is that simple discounting disregards the actual cost structure. Another reason is that the costs used in the estimate in this report, need some improvement regarding both the level of costs and the distribution over time. Still, this will probably not be enough to make the two methods align. From this perspective it also seems that the recommended discount rate of 2 percent to be used in the NA, is too high in relation to the Swedish context. The reference to the rate level at 2 percent is mentioned in the section 5.3.4 above on the net income method using Heureka. Summarily, it is used because there is a need to test the recommendations in the draft OECD handbook.

The structure of stumpage prices derived by the capitalisation of costs method might be used to improve the estimate of the consumption value method. This can be done by replacing the aggregate stumpage price with the specific ones by assortment and species used in the combined consumption value method and stumpage value method.

The net income method or net present value method depends heavily on assumptions of general equilibrium in the economy. This is the reason behind the identity of the capitalisation interest rate and the discount rate. The method also needs assumptions about future prices to be fed into the calculations. According to the System of Environmental-Economic Accounting (SEEA) (UN, 2014), the default assumption on future resource prices is that they follow the same pattern as the general inflation. This is also the reason behind the recommendation to use the national inflation target as the default assumption of the difference between the nominal interest rate and the real interest rate.

In relation to the policy initiatives to mitigate climate change, the demand on forest owners to provide carbon storage services might increase the relative scarcity of wood supply and thus put an upward pressure on timber prices far beyond the inflation rate. This will increase the resource rent in a similar way as for the oil industry. The price of raw petroleum is a good illustration of the fact that the international economy for a long time have been far from a state of general equilibrium.

The use of assumptions regarding the future is problematic from a national accounts' perspective. The NA is a statistical framework that records actual current costs. The main interest in NA lies on the volume of value added, created by human labour. Prices and volumes representing the current period are what is needed in the NA. Future events are only relevant if they influence economic agents to the extent that there is an impact on the values of current market transactions.

The recommendations for an appropriate discount rate to be applied, usually refers to a long-term interest rate preferably related to a risk-free financial instrument (government bond). However, financial markets and interest rates are rather volatile and regarding the rotation time of approximately 100 years in forestry, even long-term risk-free interest might be problematic to apply. A sensitivity analysis on the impact of plus or minus 1 percent on the discount rate was made in this project, and the result showed it had a substantial influence on the end results (see section above on Results under Net Income with Heureka system).

Another issue is whether the discount rate should refer to a financial instrument or the volume relation between value added and labour input (productivity). A relatively risk-free bond is an alternative investment option used as a default opportunity in relation to other investment options. This is a perspective from an investors point of view. The investor evaluates the probable outcome of different investment opportunities, to make an informed choice of alternative to invest in. The same is the case for a forest owner when a decision must be made regarding if and when to implement a specific silvicultural measure (thinning, fertilizing etc.).

National accounts, on the other hand, is a social accounting framework that takes the view of the entire society. The society benefits when the volume of goods and services increases and at a given volume when the labour input decreases. When the biomass in young trees gradually is transformed into biomass in mature trees, this is regarded as a quality change in output included in the NA volume estimate. The alternatives from the view of the society are which activities human labour resources should be devoted to. To answer this question, we need to make a comparison of the contribution to output (productivity) between activities and in a temporal comparison it will be the productivity change over time, that is the benchmark, which different alternatives should be compared with.

One of the most important factors to evaluate among these methods is the compilation time. Given the dates of publication for the official statistics, together with the reporting date of the EFA and National accounts deadlines even earlier, it is only a few weeks that are available for compilation, at best. The fastest methods are the aggregated methods and possibly the method based on property tax data. These require less data, which means fewer calculations. They will also be easier to automate in the long run, using statistical software programming. Fewer calculations also mean a lower risk of calculation errors, less time spent debugging etc. These faster methods should be possible to finish within a few days or up to a week.

The next group being the more detailed stumpage value and consumption value methods that are estimated to take only slightly more time, which is about a week. The most time-consuming method was the Heureka system which took several weeks, however not full-time work. Considerable time needs to be put into updating and inputting presets to run the system. Even after this further time needs to be spent understanding the details of the results and complexity of the models involved.

There is a balance that needs to be struck between compilation time and quality, so that the method chosen is the one to produce the highest quality in the time that is available. Yet also be in line with National and Environmental Accounts standards.

5.4.1 Recommendation of method

From this grant project, the recommendation for Sweden is to use a consumption value method. This is a method that accounts for differences in region, tree type and the maturity class of the trees, using differentiated stumpage prices per maturity class. This was started in this project by the simplified assumption of younger forests not having any value in one of the methods. Further refinement of this method and with guidance from Eurostat on what could be the best practice for adapting stumpage prices to different age/maturity categories, will make it possible for Sweden to use this method in the first reporting of EFA monetary table A2b in September 2025.

Given the data used in this grant project, the result for 2020 of such a method is expected to lie somewhere between SEK 440 and 650 billion. That is the range between the detailed stumpage value method and the method with no value for younger trees.

5.4.2 Remaining tasks

Several tasks remain before a finished reporting A2b monetary timber stock table can be reported in September 2025. They are listed below:

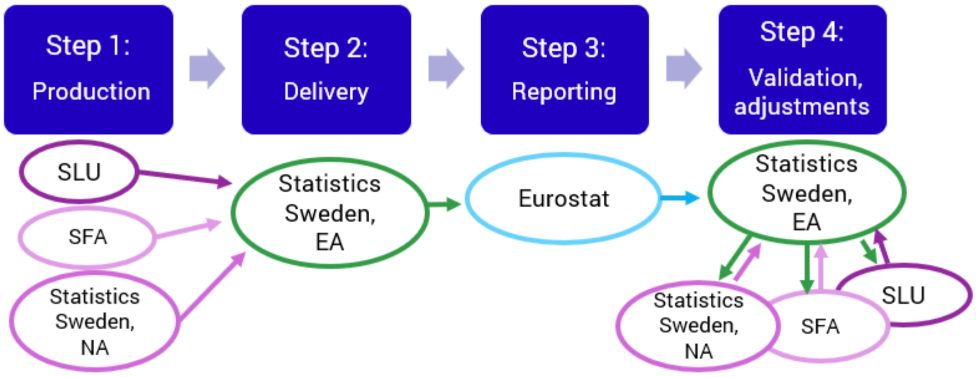
- A special focus was put into monetary valuation of the dominant FAWS category in this grant project. It stands for more than 70 percent of the timber volume in the preliminary used data. FNAWS is not to be valuated according to the EFA handbook. The remaining 9 percent of the reported timber volume is mostly in the Other Wooded Land (OWL) category. A valuation of these remaining volumes is still to be made.
- Possibly the most important assumption is involving what assortments the timber stock should be valued by. In this project, a one-year average of felling statistics was used. This needs to be expanded to use multi-annual averages, preferably 10 or 15 years. Other possibilities need to be investigated in the longer term, like using harvest machine data or forestry research studies to better bridge the gap between timber volume statistics and price statistics.
- Asking for clarification from Eurostat. There are some areas where the EFA handbook could give more guidance. Most important, it is relating to what prices to use in the valuation. Clarifying whether the costs for silviculture should be deducted in the estimated stumpage price, and what is the best practice for adjusting the price of trees that are not mature for felling.
- After seeking guidance on price differentiation, this needs to be implemented to different maturity classes to complete the consumption value method.
- Fine-tuning the calculations. The objective of this grant project was to test several valuation methods. In doing so, no dedication could be made to one single method. Now that a method is recommended, a stronger focus can be put into improving some calculations and the workflow. Among other things that need to be adjusted, is more differentiation in costs and prices. For example, costs are greater for thinning than final harvesting, and prices for different maturity classes should vary more than was applicable in this project.

6. Implementing the results and other preparations for future work

Parallel to the development of methods, the project has been working on creating a process for the annual delivery of data to the EFA questionnaire. This includes deliveries of data, both between national authorities, and from Sweden to Eurostat. The process concerns the three tables that was the focus of this project, but also table *B1 Economic aggregates of the forestry and logging industry*, that has been reported by Sweden since before. The delivery of table B1 will now be aligned with the delivery of the three new tables.

The creation of a sustainable working process is an important part of the implementation of the results of this project. The total process can be divided into four steps, visualised in Figure 6.1.

Figure 6.1. Steps in the Swedish production and delivery process of EFA



SLU: Swedish University of Agricultural Sciences, SFA: Swedish Forest Agency, NA: National accounts, Statistics Sweden, EA: Environmental accounts, Statistics Sweden

Source: Statistics Sweden

Step 1 is the production of data, according to the EFA requirements and the models that have been developed in this project. This requires documentation and routines to provide a stable production system that is not dependent on individuals or other factors that may affect the result. Step 1 concerns all three authorities that participated in the development of methods. SLU will produce data for the tables A1a and A2a. SFA will produce data for table A2b. National accounts (NA) at Statistics Sweden produce data for table B1.

Step 2 concerns the delivery of data, from the producers to the reporting administrator at Statistics Sweden's environmental accounts

(EA). For a smooth delivery, communication between the parties is important. The project recommends an annual start-up meeting, well in advance before the delivery date. In this meeting delivery dates, follow-up meetings, data quality and other related issues will be discussed, decided on, and documented.

Step 3 is the delivery of data from Statistics Sweden to Eurostat, through the EFA questionnaire. This step was tested in the project, through the delivery of preliminary data in September 2024. In the test, the delivery worked well, and no further actions were seen as necessary. The process is well documented to provide a stable and efficient delivery.

Step 4 is Eurostat's validation of the reported data and adjustments that Sweden might need to do, based on the result of the validation. This was also tested in the project, through the delivery of preliminary data. The test did not indicate any major need for adjustments. However, the project is aware of that the delivery in September 2025 might give another outcome. Consequently, there is a readiness to handle a more extensive validation result. The authorities are prepared for a potential follow-up meeting during the fall of 2025, to mutually decide how the validation result should be handled.

To provide a robust and long-term production and delivery system, the project has started the process of creating agreements between Statistics Sweden and the two producers of data, SLU and SFA. The agreements will be completed after the EFA delivery in September, when the method is fully established.

7. Conclusions

7.1. Progress and outcome

By the end of the project, the outcome is improved estimates for all the three mandatory EFA tables A1a, A2a and A2b. The project has tested and evaluated the methods that were pinpointed in the project's roadmap. Where needed, a combination of methods and new approaches have been tested. The EFA handbook was updated during 2024, and the project could use the new version to help clarify some definition issues. Detailed conclusions on the methods are described in the chapter of each table.

Since the actual delivery of data to the EFA questionnaire is in September 2025 and this project ended in March 2025, the project cannot present the actual data that will be delivered in September. The result therefore consists of pilot data tables, with preliminary figures that will be updated just before the latter delivery.

The result is also a structure for the annual working process of deliveries to the EFA questionnaire. Besides of implementing the results of producing the data, the process will consist of agreements between Statistics Sweden and the two producers of data, SLU and SFA. The project has also prepared for the EFA questionnaire transmission and validation, by making a transmission of preliminary data in September 2024.

7.2. Remaining tasks

The project has finalised most of the activities that were specified in the roadmap of the project. However, there will be a gap in time between the project end in March 2025 and the EFA data delivery in September the same year. To meet the reference time requirements for EFA, the calculations for the delivery in September must use data that was not available during the project period. Consequently, parts of the activities of this project have not been fully completed. This will be accomplished after the closing of the project, but before the reporting to the EFA questionnaire in September. More specifically, this includes:

- The data that will be used in the September EFA delivery have not been tested with the methods developed within the project. Consequently, there might be some adaption in the methods to better suit the final data. However, the differences should not be significant, as the project have used the latest data available during the project period. Details of remaining tasks are described in the methodological chapters of each table.

- The data tables presented in this report (Table A1a, A2a, A2b) contains preliminary data. The EFA delivery in September will be based on an updated data set and thus contain other figures.
- Since only preliminary data have been reported to the EFA questionnaire (in September 2024), there could be a more comprehensive validation of data when the final figures are delivered in September 2025.
- There are some areas where the EFA handbook could give more guidance. Most important, it is relating to what prices to use in the valuation. Clarifying whether costs for silviculture should be deducted in the estimated stumpage price, and what is the best practice for adjusting the price of trees that are not mature for felling. It is shown in this report that the choices of method and assumptions have a fundamental impact on the monetary value of the timber stock. It is preferable then, that the handbook is clear in providing best practises on how to adjust prices and when.
- The agreements between Swedish authorities, concerning deliveries of data, are not fully completed. They will be finished after the EFA delivery in September, when the method is fully established.

7.3. Impact and continuation

A more sustainable production process for the reporting of the EFA questionnaire was an important driving force for the project. The short-term effect of the result is the improved ability to produce all the mandatory tables in the EFA questionnaire, according to the proposal for amending Regulation 691/2011. The medium and long-term impact is improved quality in other statistical areas, where forest statistics is the main data source, e.g., the reporting of the LULUCF sector in the greenhouse gas inventory. Another medium and long-term effect is transition to new innovative data sources such as using remote sensing data for producing statistics.

The target group is mainly the European commission which specifically proposed the amendment of 691/2011 to produce forest accounts. Since Sweden is a forest rich country, the results of this project will be important in a European context and for the overall quality of the EU forest accounts. Many other countries have similar NFI. Consequently, the results of this project could be useful for other data producers, both in the short and medium term.

Within Sweden, the project has improved the cooperation between the three national authorities who have collaborated in this project. There had previously not been much cooperation between the National accounts and SLU, but this project has established contacts between them. This will improve the quality and effectiveness in the EFA production, and in other products and tasks that will benefit from a better cooperation between the authorities.

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