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# Methodology of monitoring wood sources and consumption in the Czech Republic

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**Abstract:** Currently, it is difficult to identify correct data on wood sources and their consumption in the Czech Republic. Official statistics of wood production are relatively limited to obtaining data that accurately captures the objective wood production, which would enable the observation of the direction or consumption of particular tree species or products. This uncertainty is then transferred to the wood flow for industrial and energy processing, and it is not possible to compose a detailed picture of how much wood and which sources enter into the wood processing and how large the total material flow is. The aim of this paper is to present an option for how to determine this lack of valid information that enables clear outcomes necessary for decision making by means of the recalculation of wood sources consumed in the Czech Republic, using the data of processing capacities and foreign trade. The reverse model better expressed a conversion value of roundwood into the products and allowed optimal approximation in the wood sources assessment.

**Keywords:** forest-based sector; conversion factors; reverse method; wood flow

Development of the wood-processing industry is a complex issue where each investor, aside from the financial and technological decisions, first explores the industry's resource options. The availability of sufficient volume and appropriate raw material quality for primary processing is one of the basic conditions for successful investment and operation of wood-processing capacities. Knowledge of the total wood production and especially the structure of t produced wood enables better assessment of operational, technological, and business risks. The wood flow structure gives basic information about the available raw materials for each type of processing, however, only if information is available about the wood production structure. Otherwise, it is necessary to conduct an inverted procedure and reconstruct the wood flow based on the production of primary processing. This procedure provides important inputs for examining the efficiency of processing structure and its potential. It is very important for tracking the global competitiveness of the forest industry and it enables comparing different wood flow models in the processing of wood volume or total created value.

While the wood flow issue has been treated in other countries, it has not been mentioned in the Czech Republic. The analysis of the tools and methods currently in use for reporting woody biomass availability in 21 European countries, provided by Barreiro et al. (2016), has shown that most countries use National Forest Inventory-oriented models, whereas the others use methods based on forest management plans.

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The approach to the wood flow and its interpretation contains several options for a balanced approach, which is best captured in Mantau (2015), who concluded this from the available information about wood sources and the volume of its utilization or consumption. This approach is simple, clear, and effective in the demonstration of the transformation of primary wood sources into the products and of the co-production used for further types of processing or consumption (referred to as 'cascade'). It is possible to identify the strengths and weaknesses of processing and provide optimizations so that the wood flow will bring the greatest potential.

The cascading principle, by presenting the utilization of wood resources in the German region, was used in the study of Taskhiri et al. (2016), which focused on the logistics networks for wood flow. The cascade utilization is considered the most suitable from the logistic point of view. The design of a quantitative wood flow chart in Japan was constructed by Kobayashi et al. (2017) with an aim to find possibilities for wood self-sufficiency.

Lenglet et al. (2017) applied a similar approach to Mantau's for material flow in the context of the climate change policy and energy transformation for the use of wood for energy purposes and described the wood flow in France. Even in this work, he criticized the need to systematize conversion units and consumption factors within the flow of material for each product and raw material in relation to the applied technology. Otherwise, it is necessary to use certain limitations or mathematical and statistical methods.

A different approach should be applied when there is neither reliable nor complete data on wood sources and their utilization. It may be the applied method of Latta et al. (2013) that contains the models implemented so far and their mutual relations to express the balance between the wood sources and their utilization. It is a very complex approach. However, this approach is limited to the global level of wood sources and consumption, and it can only be used for the national level with the modification and supplementation of methods for national or local levels.

The application of the approach described by Džubur et al. (2017) is s practical starting point for eliminating the problems of uncertainty (validity and availability) of the data needed for each wood flow model. Mathematical approaches are applied to fill in missing data based on a set of variables and their dependence functions when using roundwood in various consumptions with the help of fuzzy logic. This approach eliminates the need for the demanding, and often impossible, detection of accurate data. However, it requires a complete model description of wood sources as well as consumption. It also demands the most accurate conversion factors for the material use of roundwood in different products and energy transformation. This mathematical modelling is basically a function in which one can gradually complement and specify the applied constants and variables.

To include uncertainties and interdependencies between stages of the wood supply chain and resource constraints, a simulation model of wood supply chains was developed and presented by Mobini et al. (2013). The model showed values of particular types of costs in the wood supply chain.

In the Czech Republic, several authors have dealt with wood sources and their determination, such as Kupčák and Pek (2015), who in the paper "The Level of the Wood Raw Material Base Processing in the Czech Republic", focused on the wood source balance and pointed to their minimal level of use, based on the available official data sources (data from Ministry of Agriculture of the CR and Ministry of Industry and Trade of the CR). Trend indicators of the processing apply company data so that a development database necessary for the production stability assessment can be created. From this point of view, the conclusions of the work can be taken as correspondent or comparative with the findings obtained in the analyses necessary for this work.

In summary, in the last few years, the issue of the efficiency of wood use has become the object of exploration in a wider context than just material utilization. The methods and processes are investigated to find a balance or rather a dynamic equilibrium between resources and consumption while questioning the optimal processing structure and how to achieve it, or how to find the minimum feasible loss.

This study deals with the determination of wood consumption data in the Czech Republic. It indirectly shows the minimum volume of wood production in the Czech Republic which is essential to fill the primary processing capacities of wood. The objective of the paper is to propose and analyse the method of identification of wood sources so that some limitations, inhibiting the more accurate expression of wood flow in the application of mathematical and statistical models, can be replaced.

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## MATERIAL AND METHODS

The proposal of a methodology for the monitoring of wood sources and its consumption requires several input analyses. A framework for the methodology of wood flow detection is defined as follows.

Sources of roundwood (forest biomass): analysis of available sources of information and evaluation of the general processing potential of individual categories of available wood. The source of information is the Green Report of the Ministry of Agriculture of the Czech Republic (MA) (http://eagri.cz/public/web/en/mze/publications/publications-forest) and statistical data of the Czech Statistical Office (CSO) for forestry (https://www.czso.cz/csu/czso/lesnictvi-2016). Within the analysis, limitations and additional values are identified to gain a comprehensive conception of wood supplies for domestic processing. The year 2016 was chosen because of the best data availability.

Wood import and export (foreign trade balance): Analysis of roundwood export and import for determining the volume in the wood flow processing is focused on the overall trend of the identifiable products (at least at the level of roundwood products) according to the MA and the CSO. Foreign trade data published by the MA were based on the data issued by the CSO. Foreign trade data were obtained from two systems, Intrastat and Extrastat. In the Intrastat report, the data was acquired directly from the companies (sending and receiving) in connection with the data on value added tax (VAT) and trade with the European Union (EU) countries. Mathematical and statistical calculations were part of Intrastat data processing and so the loss of information was compensated as a consequence of non-response and implementation of statistical thresholds. The remaining part of the foreign trade realized, mainly with non-European Union countries, is still subject to common customs procedures. Customs Declarations (single administrative documents) are a source of statistical data for the Extrastat report. In the foreign trade section, this study identifies the volume of wood export and import in the correction of non-conformities and compares it with available official data.

Primary industrial processing without further distinction in energy production and consumption: The wood volume entering the processing is reported in the statistical report of the Ministry of Agriculture elaborated by the Czech Statistical Office (MA 2016; CSO 2016).

Within the proposal of the monitoring methodology for the wood flow, this study is focused on the limited data sources concerning the input of roundwood and its correction. The second part seeks to express the real wood consumption through application of the conversion factors of roundwood into the products but in a reverse way. This means that from the known data of the representatives of the companies in the primary processing, the study will express the necessary volume of wood which should be accounted for in the processing. By comparing the data on wood sources and data on company wood consumption, the study determines compliance or differences that need to be treated for further specification of the wood flow in the Czech Republic.

Generally, it is possible to express this procedure as a process where it is needed: (1) to find out types of primary wood processing; (2) to assign the individual types of processing to the average values of the disintegration of the material balance of the yield of 1 $m^3$ of input wood (conversion factors); (3) to determine production volumes of individual types of processing; and (4) to determine production structure and consumption of by-products within one type of primary processing and between different types of processing.

This model allows determining the necessary wood volume input based on the production data and knowledge of the conversion of roundwood into the products.

The methodology enhances only primary wood processing and will not treat the wood consumption out of industrial processing, it does not analyse the wood flow for energy consumption or household consumption, nor will it examine in detail the wood consumption within the energy company production of primary processing.

## RESULTS AND DISCUSSION

### Results of input analyses

Official statistical monitoring of wood production presents an under bark volume of wood obtained from the statistically restricted group of information providers. It means that the statistics do not provide information on total wood production in the Czech Republic, the group of the forest owners up to 200 ha is excluded. CSO data concerning total wood production as well as major product groups showed that currently the coniferous wood

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noticeably prevails. Approximately 9.8 million $m^3$ of logs have wide industrial utilization. There is a high proportion of firewood in both deciduous and coniferous wood. The question is whether it is idle wood for industrial processing. For deciduous wood, firewood makes up to 47% of the total volume delivered.

The first part of the wood source analysis for the wood flow in industrial processing identifies the following factors:

– roundwood production is reported only as a subset, it does not include all forest owners and wood harvesting out of a specified group of respondents,
– it provides no information on the supply of forest biomass and wood or forest residues and wood chips produced in the forest,
– there is no statistical monitoring of the bark volume from the forest production,
– there is a considerable difference in the statistical monitoring of wood production between the Ministry of Agriculture and National Forest Inventory (NFI identifies average annual production at the level of 21.83 million $m^3$ wood) (Adolt et al. 2016),
– current official data about forest statistics does not give necessary data for an energy consumption assessment,
– classification of wood products and their utilization in the industrial processing is not interconnected with the consumption of the primary processing sector.

One of the common and frequently communicated problems of CSO data is their unreliability in the values expressing technical units. Because the financial statement is due to the relation to VAT, the main required information, it often happens that respondents do not pay much attention to the accuracy of the values expressing the volume in technical units. There is no way but to proceed with several corrections based on mathematical and statistical methods. This is why the Ministry of Agriculture has to use some methods to correct basic data provided by the CSO. However, these recalculations are made over the aggregation of the primary data and not over the individual records of the respondents.

To monitor and evaluate foreign trade properly, it is necessary to use the authors' own procedure to remove the apparent mistakes from the detailed foreign trade data. Application of the limits or elimination of the extremes in primary data allows the capture of the greatest deviations and the recalculation of the correct values based on the historical development of the products. Thus, more realistic values of the detailed items can be obtained, providing better conclusions.

**Input data correction**

Wood production data was based on the sources of the CSO Forestry for 2016. Roundwood export and import data were taken from two sources. The first was the corrected CSO database according to its own algorithm, and the second source was the MA Green Report for 2016. The corrected CSO database is the foreign trade statistics data corrected by the largest variations in the number of technical units. The data of the Ministry of Agriculture was taken from their own sources and sources from the CSO. The CSO data correction algorithm is based on the long-term average development of individual items and identifies the extremes of the reported values and according to the weight and price values it corrects the real value in technical units.

Foreign trade statistics contain no detailed import and export classification allowing for the composition of a complete section of individual tree species reported by the CSO in the section Forestry – harvesting. Therefore, aggregations of spruce, fir species, and others were created, only pine was in relation to the foreign trade items. In the case of deciduous trees, the aggregation was made for oak, and in the section others were the remaining tree species, apart from beech, birch, and poplar. Corrections of the roundwood export for the year 2016 were from 1 732 059 $m^3$ to 140 199 $m^3$. Further on, the value of export and import is used according to the corrected data by its own methodology (reversely verifiable and readily corrected for more correct values).

Table 1 is the application of the corrected data database of the CSO and MA with the calculation per consumption (Harvesting – Export + Import). The final difference in the consumption is not essential, and it is clear that the Ministry of Agriculture is now more interested in this issue, because this difference was even 780 000 $m^3$ after the correction in the year 2016. At this level, domestic consumption was dominated by the consumption of spruce and pine. For this purpose, the basic data on wood deliveries was obtained in the amount of 14.1 million $m^3$ of wood under bark.

However, wood production is reported only in the area of 93.17% (use of Forest Management In-

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stitute Information on Czech Forests data with a number of forest management units, published by Matějíček 2014). It is therefore necessary to include the volume of wood harvested by owners under 200 ha. This is so far the only available data about the share of forest owners. After applying a relative recalculation for the area of 6.83% (1 291 414 $m^3$), the total wood production would be 18 907 697 $m^3$, which was a proportional increase considering the same average harvesting per one hectare, and wood consumption in the Czech Republic would then be 15 417 026 $m^3$. It was divided by an even share of deciduous and coniferous wood as for land above 200 ha. Then, the coniferous wood harvested by all owners would be 17.1 million $m^3$ and for deciduous wood 1.82 million $m^3$.

Table 1. Czech Statistical Office (CSO) corrected data and Ministry of Agriculture of the Czech Republic (MA) data of wood production by tree species in 2016 (in $m^3$ without bark)

| Tree species | Wood production (included self-production) | CSO | | | MA | | |
|---|---|---|---|---|---|---|---|
| | | export | import | consumption | export | import | consumption |
| Coniferous and deciduous total | 17 616 553 | 5 177 709 | 1 686 768 | 14 125 61 | 5 226 00 | 1 795 00 | 14 185 55 |
| Coniferous total | 15 923 807 | 5 034 094 | 1 486 316 | 12 376 03 | 5 079 00 | 1 500 00 | 12 344 81 |
| Norway spruce | 13 965 499 | | | | | | |
| Blue spruce and other spruces | 20 364 | | | | | | |
| Silver fir | 111 629 | | | | | | |
| Grand fir and other firs | 3 705 | | | | | | |
| Spruces and firs total | 14 101 197 | 4 547 892 | 1 215 698 | 10 769 00 | 4 566 00 | 1 227 00 | 10 762 19 |
| Douglas fir | 30 297 | | | | | | |
| Pine | 1 342 189 | 224 395 | 253 671 | 1 371 465 | 240 000 | 255 000 | 1 357 189 |
| Eastern white pine | 25 623 | | | | | | |
| Larch | 424 038 | | | | | | |
| Mountain pine | 456 | | | | | | |
| Other coniferous | 7 | | | | | | |
| Other | 480 421 | 261 807 | 16 947 | 235 561 | 273 000 | 18 000 | 225 421 |
| Deciduous total | 1 692 746 | 143 615 | 200 452 | 1 749 583 | 147 000 | 295 000 | 1 840 746 |
| Pedunculate oak | 219 811 | | | | | | |
| Sessile oak | 148 677 | | | | | | |
| Other oaks | 22 056 | | | | | | |
| Oaks total | 390 544 | 10 243 | 51 883 | 432 184 | 13 000 | 135 000 | 512 544 |
| Beech | 746 856 | 103 820 | 91 960 | 734 996 | 104 000 | 103 000 | 745 856 |
| Hornbeam | 46 609 | | | | | | |
| Maple | 38 139 | | | | | | |
| Ash | 123 577 | | | | | | |
| Elm | 1 496 | | | | | | |
| Acacia | 17 526 | | | | | | |
| Birch | 162 406 | 2 318 | 12 390 | 172 478 | 2 000 | 12 000 | 172 406 |
| Alder | 35 088 | | | | | | |
| Linden | 53 993 | | | | | | |
| Poplar and aspen | 60 033 | 2 413 | 2 855 | 60 475 | 3 000 | 4 000 | 61 033 |
| Willow | 5 194 | | | | | | |
| Other | 332 907 | 24 821 | 41 364 | 349 450 | 25 000 | 41 000 | 348 907 |

Source: CSO (2016) and current study calculations, Ministry of Agriculture (MA 2016)

Table 2. Wood production by tree species after recalculation in 2016 (in $m^3$ with bark)

| Wood species | Wood production (included self production) | Wood production by all owners | All owners with bark | Bark | Production by all without fuel wood with bark | Deliveries of wood without bark | Export roundwood | Export others | Import roundwood | Import others |
|---|---|---|---|---|---|---|---|---|---|---|
| Coniferous and deciduous total | 17 616 553 | 18 907 967 | 20 889 637 | 1 981 670 | 16 391 873 | 12 900 932 | 3 519 077 | 1 658 632 | 315 113 | 1 371 65 |
| Coniferous total | 15 923 807 | 17 091 131 | 18 800 263 | 1 709 132 | 15 427 422 | 11 879 644 | 3 473 472 | 1 560 622 | 248 635 | 1 237 68 |
| Norway spruce | 13 965 499 | 14 989 266 | 16 488 209 | 1 498 943 | 13 530 159 | | | | | |
| Blue spruce and other spruces | 20 364 | 21 857 | 24 043 | 2 186 | 19 729 | | | | | |
| Silver fir | 111 629 | 119 812 | 131 794 | 11 981 | 108 149 | | | | | |
| Grand fir and other firs | 3 705 | 3 977 | 4 374 | 398 | 3 590 | | | | | |
| Spruces and firs total | 14 101 197 | 15 134 911 | 16 648 419 | 1 513 508 | 13 661 627 | 10 329 433 | 3 255 633 | 1 292 259 | 215 808 | 999 890 |
| Douglas fir | 30 297 | 32 518 | 35 770 | 3 252 | 29 353 | | | | | |
| Pine | 1 342 189 | 1 440 581 | 1 584 640 | 144 060 | 1 300 350 | 1 329 626 | 147 686 | 76 709 | 29 559 | 224 112 |
| Eastern white pine | 25 623 | 27 501 | 30 252 | 2 750 | 24 824 | | | | | |
| Larch | 424 038 | 455 123 | 500 636 | 45 513 | 410 820 | | | | | |
| Mountain pine | 456 | 489 | 538 | 49 | 442 | | | | | |
| Other | 487 421 | 523 639 | 575 204 | 52 564 | 472 445 | 220 585 | 70 153 | 191 654 | 3 268 | 13 679 |
| Deciduous total | 1 692 746 | 1 816 836 | 2 089 374 | 272 538 | 964 451 | 1 021 288 | 45 605 | 98 010 | 66 478 | 133 974 |
| Pedunculate oak | 219 811 | 235 925 | 271 315 | 35 390 | 125 238 | | | | | |
| Sessile oak | 148 677 | 159 576 | 183 514 | 23 938 | 84 710 | | | | | |
| Other oaks | 22 056 | 23 673 | 27 224 | 3 551 | 12 567 | | | | | |
| Oaks total | 390 544 | 419 174 | 482 052 | 62 879 | 222 515 | 264 155 | 6 759 | 3 484 | 25 777 | 26 106 |
| Beech | 746 856 | 801 606 | 921 852 | 120 246 | 425 525 | 413 665 | 37 410 | 66 410 | 37 766 | 54 194 |
| Hornbeam | 46 609 | 50 026 | 57 530 | 7 504 | 26 556 | | | | | |
| Maple | 38 139 | 40 935 | 47 075 | 6 141 | 21 730 | | | | | |
| Ash | 123 577 | 132 636 | 152 532 | 19 896 | 70 409 | | | | | |
| Elm | 1 496 | 1 606 | 1 847 | 241 | 852 | | | | | |
| Acacia | 17 526 | 18 811 | 21 633 | 2 822 | 9 986 | | | | | |
| Birch | 162 406 | 174 311 | 200 459 | 26 148 | 92 532 | 102 604 | 1 436 | 882 | 2 935 | 9 455 |
| Alder | 35 088 | 37 660 | 43 309 | 5 649 | 19 992 | | | | | |
| Linden | 53 993 | 57 951 | 66 644 | 8 693 | 30 763 | | | | | |
| Poplar and aspen | 60 033 | 64 434 | 74 099 | 9 666 | 34 204 | 34 646 | | 2 413 | | 2 855 |
| Willow | 5 194 | 5 575 | 6 411 | 836 | 2 959 | | | | | |
| Other | 344 192 | 369 423 | 424 840 | 55 416 | 196 106 | 206 219 | | 24 821 | | 41 364 |

Source: own calculation according to input data of the Czech Statistical Office (CSO 2016) and Ministry of Agriculture of the Czech Republic (MA 2016)

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The bark volume should be added to this figure as the basic potential of material utilization, for coniferous trees the coefficient was 0.90909 and for deciduous trees it was 0.86956 (see Decree 84 on Forestry Planning, paragraph 7, part L). Therefore, 1 981 670 $m^3$ of bark was obtained. This volume must be further corrected in the flow of processing, another volume is obtained from debarking saw logs and another from pulpwood. Firewood is not debarked. It is necessary to exclude from the wood balance the amount of firewood that is immediately consumed and does not enter the total flow of industrial processing. Firewood volume for 2016 was 2.344 thousand $m^3$. After the recalculation for all forest owners, the firewood volume would be 2 516 094 $m^3$.

The values of consumption and bark volume are adjusted. The volume of the bark exported has to be deducted and the volume of the bark of imported wood has to be added (add the balance). In the foreign trade a difference between the import and export of bark is the wood balance in the amount of 346 000 $m^3$. This means that, in total, 1 635 414 $m^3$ of bark enters the wood flow, without bark from the import and export balance of roundwood. The volume of firewood bark still has to be deducted, which amounts to 294 236 $m^3$ (calculated as the difference between the wood harvested by all owners and the volume of wood of all owners without firewood; thus, the volume of firewood is obtained and the volume of bark using the bark coefficient is calculated). Accordingly, it does not enter into the wood flow as a raw material. Finally, the volume of the bark in the raw material flow would be 1 341 178 $m^3$.

By subtracting firewood from harvesting by all owners (2 516 094 $m^3$), 16 391 873 $m^3$ of wood was obtained and after deduction of export and addition of import, the basic volume of delivered wood for processing in the Czech Republic was obtained, which was 12 634 216 $m^3$ without bark. Therefore, 12 900 932 $m^3$ of wood without bark and 1 341 178 $m^3$ of bark enter the consumption without firewood. However, it is necessary to exclude or adopt a statement on the area utilization of firewood outside industrial processing. Residues and woodchips in the amount of 1.9 million $m^3$ (CSO) are other input items.

To summarize, the final inputs were 12.9 million $m^3$ of wood, 1.3 million $m^3$ of bark, and 1.9 million $m^3$ of biomass (see Table 2).

**Method of reverse determination of roundwood input for processing**

A reverse approach was applied to create the industrial wood flow in the primary production (Table 3). This principle requires creating a database of roundwood processors and their typological orientation of the prevailing production and applied technologies. All this information is being identified, sustained and updated over the long term by the authors. The data on wood sources is used as an input for modelling the flow of wood at the level of gross aggregates. Table 3 contains production values from the company data, calculated for the wood consumption in the mutual cascade. By the model limitation, the application of the average production prices is necessary to determine the physical volume of production divided into main and secondary production so that the total sales are in relation to the structure of sales of products, materials and own consumption.

This method requires a detailed analysis of the economic values related to the transformation of the purchased material into the product. When applying this method, it is possible to express the wood volume necessary for processing with a defined inaccuracy measure and determine the deviation from wood production data.

The identified primary processing segments, according to the wood flow analysis, are: wood impregnation, coniferous roundwood (SW), deciduous roundwood, veneer, coniferous plywood, deciduous plywood, OSB boards, chipboards (DTD), MDF (in joint production with DTD and coniferous SW), pulp, energy production. These primary processing segments are key segments of the forest industry and the roundwood enters in various products. In terms of the total volume, there are excluded primary processing segments of the furniture industry (apart from the veneer) and wood construction from the saw logs, since it is very difficult to identify the roundwood consumption and it presents only a small part of the total wood consumption.

## CONCLUSIONS

The analysis of input data showed that the official data on wood sources in the Czech Republic are incomplete and inaccurate. Therefore, they do not allow their application to the wood flow without additional calculations and further investigation of the wood consumption in the energy segment, both in

Table 3. Industrial wood flow in the primary production in 2016

| Wood consumption (m³) 13 724 007 | | | | Input ratio 88% | Produced vol. 12 064 932 m³ | | Industrial wood flow in primary production – basic model | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Consumption (m³) | | | | deficit/plus | unlocated material | production | production (m³) | | | | | | | |
| | | | | –823 075 (m³) | 412 403 (m³) | 12 064 932 (m³) | 7 678 500 | | 413 303 | –113 540 | | 112 641 | | |
| Bark | recyl | sawdust | chips | wood 12 900 932 | processing | product 12 064 932 | material balance (%) | primary production 7 678 500 | dry up 190 118 | chips 2 003 303 | sawdust 1 351 840 | loss 365 793 | bark 1 012 641 | secondary production 18 649 | total without bark |
| 900 000 | 440 000 | 1 465 380 | 1 590 000 | 7 948 276 | sawnwood production coniferous wood | sawnwood | 55 | 4 610 000 | | | | | | | |
| | | | | | | dry-up | 2 | | 158 966 | | | | | | |
| | | | | | | woodchips | 23 | | | 1 828 103 | | | | | |
| | | | | 7 948 276 | | sawdust & cuts | 15 | | | | 1 182 241 | | | | |
| | | | | | | loss | 2 | | | | | 158 956 | | | |
| | | | | | | bark | 8 | | | | | | 635 852 | | 7 948 276 |
| | | | | 511 321 | sawnwood production deciduous wood | sawnwood | 53 | 271 000 | | | | | | | |
| | | | | | | dry-up | 3 | | 15 340 | | | | | | |
| | | | | | | woodchips | 23 | | | 117 604 | | | | | |
| | | | | 511 321 | | sawdust & cuts | 18 | | | | 92 038 | | | | |
| | | | | | | loss | 3 | | | | | 15 340 | | | |
| | | | | | | bark | 8 | | | | | | 30 679 | | 511 321 |
| | | | | 32 258 | impregnation | sawnwood | 90 | 30 000 | | | | | | | |
| | | | | | | dry-up | 2 | | 645 | | | | | | |
| | | | | | | woodchips | 3 | | | 968 | | | | | |
| | | | | 32 258 | | loss | 2 | | | | | 645 | | | |
| | | | | | | bark | 2 | | | | | | 645 | | 32 258 |
| | | | | 63 636 | coniferus plywood | veneer | 55 | 35 000 | | | | | | | |
| | | | | | | dry up | 8 | | 5 091 | | | | | | |
| | | | | | | residues products | 9 | | | | | | | 5 727 | |
| | | | | | | woodchips | 20 | | | 12 727 | | | | | |
| | | | | 63 636 | | sawdust | 5 | | | | 3 182 | | | | |
| | | | | | | loss | 3 | | | | | 1 909 | | | |
| | | | | | | bark | 7 | | | | | | 4 455 | | 63 636 |
| | | | | 53 659 | deciduous plywood | veneer | 41 | 22 000 | | | | | | | |
| | | | | | | dry up | 6 | | 3 220 | | | | | | |
| | | | | | | residues products | 4 | | | | | | | 2 146 | |
| | | | | | | woodchips | 38 | | | 20 390 | | | | | |
| | | | | 53 659 | | sawdust | 7 | | | | 3 756 | | | | |
| | | | | | | loss | 4 | | | | | 2 146 | | | |
| | | | | | | bark | 7 | | | | | | 3 756 | | 53 659 |

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Table 3 to be continued

| Wood consumption (m³) 13 724 007 | | | | Input ratio 88% | Produced vol. 12 064 932 m³ | | Industrial wood flow in primary production – basic model | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Consumption (m³) | | | | deficit/plus | unlocated material | production | | | production (m³) | | | | | | |
| | | | | –823 075 (m³) | 412 403 (m³) | 12 064 932 (m³) | | 7 678 500 | | 413 303 | –113 540 | | 112 641 | | |
| Bark | recycl | sawdust | chips | wood 12 900 932 | processing | product 12 064 932 | material balance (%) | primary production 7 678 500 | dry up 190 118 | chips 2 003 303 | sawdust 1 351 840 | loss 365 793 | bark 1 012 641 | secondary production 18 649 | total without bark |
| | | | | 97 959 | | veneer | 49 | 48 000 | | | | | | | |
| | | | | | | dry up | 7 | | 6 857 | | | | | | |
| | | | | | | residues products | 11 | | | | | | | 10 776 | |
| | | | | | veneers | woodchips | 24 | | | 23 510 | | | | | |
| | | | | 97 959 | | sawdust | 5 | | | | 4 858 | | | | |
| | | | | | | loss | 4 | | | | | 3 918 | | | |
| | | | | | | bark | 7 | | | | | | 6 857 | | 97 959 |
| | | | | 958 677 | | wood | 62 | 595 000 | | | | | | | |
| | | | | | | dry-up | 33 | | 316 694 | | | | | | |
| | | | | | OSB | sawdust | 4 | | | | 38 387 | | | | |
| | | | | 958 677 | | loss | 1 | | | | | 9 597 | | | |
| | | | | | | bark | 9 | | | | | | 47 914 | | 959 677 |
| | | | | 59 180 | | wood | 61 | 91 000 | | | | | | | |
| | | | | | | dry-up | 37 | | 55 197 | | | | | | |
| | | | 90 000 | | MDF | sawdust | 1 | | | | 1 492 | | | | |
| | | | | 149 180 | | loss | 1 | | | | | 1 492 | | | |
| | | | | | | bark | 7 | | | | | | 4 143 | | 149 180 |
| | | | | 3 340 525 | | wood | 4.85 | 946 500 | | | | | | | |
| | | | 1 250 000 | | pulp | loss | 5 | | | | | 167 026 | | | |
| | | | | 4 510 525 | | bark | 7 | | | | | | 233 837 | | 946 500 |
| | | | | 634 615 | | wood | 65 | 1 030 000 | | | | | | | |
| | | | | | | dry-up | 33.7 | | 534 015 | | | | | | |
| | 440 000 | 310 000 | 200 000 | | chipboard | sawdust | 1.00 | | | | 15 846 | | | | |
| | | | | 1 584 615 | | loss | 0.30 | | | | | 4 754 | | | |
| | | | | | | bar | 7 | | | | | | 44 423 | | 1 584 615 |
| | | | | 0 | | sawdust | 2.35 | 332 000 | | | | | | | |
| | | 780 200 | | | pellets (t) | loss | 0.90 | | | | | 7 022 | | | |
| | | | | 780 200 | | | | | | | | | | | 332 000 |

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Table 3 to be continued

| Wood consumption (m³) 13 724 007 | | Input ratio 88% | Produced vol. 12 064 932 m³ | Industrial wood flow in primary production – basic model | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Consumption (m³) | deficit/plus | unlocated material | production | | | | production (m³) | | | | | | | | | |
| | −823 075 (m³) | 412 403 (m³) | 12 064 932 (m³) | | | material balance (%) | 7 678 500 primary production 7 678 500 | dry up 190 118 | 413 303 chips 2 003 303 | −113 540 sawdust 1 351 840 | loss 365 793 | 112 641 bark 1 012 641 | secondary production 18 649 | total without bark |
| Bark | | processing | product 12 064 932 | | | | | | | | | | | |
| recycl | | | | | | | | | | | | | | |
| sawdust | 325 180 | | sawdust | | | 2.29 | 152 000 | | | | 3 133 | | | 152 000 |
| chips | | | loss | | | 0.90 | | | | | | | | |
| wood | 22 900 | | briquettes (t) | | | | | | | | | | | |
| | 348 080 | | | | | | | | | | | | | |
| | 0 | | energy | | | 100 | 1 000 000 | | | | | | | 1 000 000 |
| | 1 000 000 | | | | | | | | | | | | | |
| Bark | 50 000 | | | | | | | | | | | | | |
| recycl | 50 000 | | | | | | | | | | | | | |
| sawdust | 900 000 | | | | | | | | | | | | | |
| chips | | | | | | | | | | | | | | |
| wood | 12 900 932 | | | | | | | | | | | | | |

OSB – oriented strand board; MDF – medium density fibreboard

the consumption of wood biomass produced in the forest, outside the forest, and at the processors; this field is not directly monitored.

There is a need to change the monitoring of wood production and roundwood foreign trade because the current approach to data collection is unreliable and does not provide confidence in the correct utilization of information. Corrections and recalculation of official source data presented in this paper have shown differences in wood inputs into processing, from 14.125 to 12.90 million m³ of roundwood, 1.34 million m³ of bark and 1.9 million m³ of biomass.

The reverse model better expressed the effectiveness, efficiency, and conversion value of roundwood into the products. Methods developed into the mathematical model, with the application of fuzzy logic method, allowed for the definition and optimum approximation in the wood sources assessment. Using the reverse method to determine the volume of wood sources entering wood processing, it was found out that the produced volume of roundwood is somewhat lower than the recalculated value, 12.06 million m³ and wood consumption is 13.72 million m³. This approach enabled the assessment of other variables applied in relation to the overall wood flow and the materials within the production, such as optimizing transport or changing the processing structure by adding a more efficient processing technology.

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