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EFORWOOD

Tools for Sustainability Impact Assessment

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Thematic Priority: 6.3 Global Change and Ecosystems

Deliverable PD 3.0.3

Case study "Baden-Württemberg"

Final report

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Further use of this report:

- *M2-M5 Definition and description of the regional case study “Baden-Württemberg”*

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1 Summary

This report gives an overview on the agreed definition of the case study “Baden-Württemberg” as one of five case studies (EU, Västerbotten, Iberia, Scotland) investigated in the integrated R&D project EFORWOOD. It was developed to provide a database for the ToSIA tool (Tool for Sustainability Indicator Assessment) to be tested. This report summarises, the approaches and assumptions applied to define processes and material flow in the forestry-wood chains for the different sectors and gives details on the topology of the case study “Baden-Württemberg”as it is stored in the “Eforwood Database Client”, the underlying database for calculations in ToSIA.

Chapter 2 describes the general considerations on the Baden-Württemberg case study in the framework of the EFORWOOD project. Chapter 3.1 summarises the structure of the forest-wood based sector in Baden-Württemberg as it was found for the reference year 2005 and describes the considerations to define the system boundaries of this regional case.

The subsequent chapters report on the approaches applied to define the individual processes in the different stages of the forestry wood chains from natural production (Module 2, Chapter 3.2), to allocation and transport (Module 3. Chapter 3.3-3.4), to production, manufacturing and consumption of fibre products (Modules 4-5, Chapter 3.5.1), wooden products (Modules 4-5, Chapter 3.5.2) and bio-energy from wooden resources (Modules 4-5, Chapter 3.5.3). This includes description of the processes and an assessment of the data quality of the indicators and material data available.

Chapters 4 and 5 describe the methodology used to develop the application of the commonly agreed reference futures A1 and B2 (IPCC, 2000) in this case study and the application of a bio-energy scenario on top of reference future A1. Chapter 6 summarises the experience gathered in data collection and data quality control of the data provided in the database “Regional case study Baden-Württemberg”.

2 General structure of case study “Baden-Württemberg”

The case study Baden-Württemberg is one of five case studies undertaken within the EFORWOOD framework. This case study is regional defined and aims to describe the network of forestry-wood chains in Baden-Württemberg including imports into the region and exports out of the region (Figure 1).

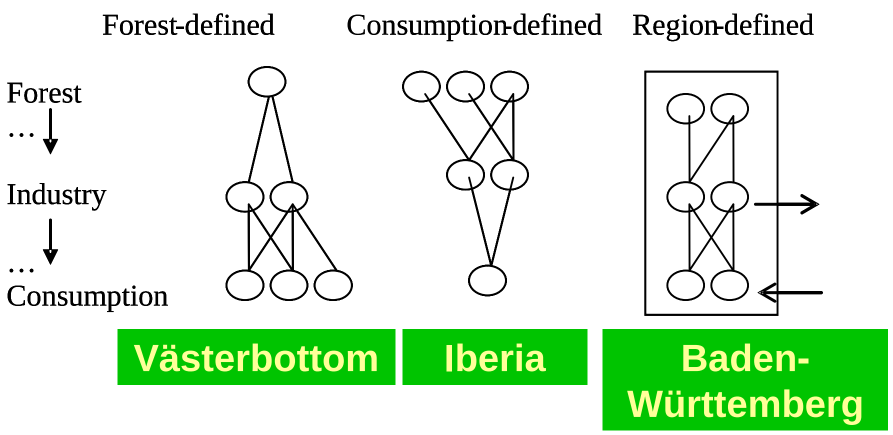

Figure 1: Case studies undertaken in the framework of the EFORWOOD project

The case study Baden-Württemberg is regarded to represent the Central European forestry-wood-chains which are characterised by a large variation of forest types based on a diverse silvicultural management, stands with mixtures of broadleaved and softwood species, and a wide age range of the stands. The challenge of this highly diversified forest production results in a highly diversified wood-based industry with a heterogeneous structure in mill size and degree of specialisation in production as well as in a multitude of linkages between the different industries.

Baden-Württemberg as geographical region within Europe covers this high degree of diversification and specialisation of forest and wood industry as described in chapter 3. Baden-Württemberg as industrial base is characterised both by highly advanced technology industries of international importance like automobile or chemical industries, and on the other hand strongly influenced by the locally important rural based agricultural and forestry sector. Forestry and wood-based industry contribute about 7 % to Baden-Württemberg’s GDP (in comparison to 2% on an all-Germany level).

The wood-based industry present in Baden-Württemberg also is characterised by the contrast between private-owned small and medium sized companies producing for the local and regional market on one hand and large consortia operating internationally. The boarders to France and Switzerland additionally introduce the challenge of international material flows across borders to the case study.

The large share of the forestry and wood-based industry sector to the economic strength of Baden-Württemberg, and the representation of the forestry and wood-based industry in its high diversification makes the region Baden-Württemberg a typical example of the Central-European area in the Eforwood context. The Baden-Württemberg case study in its structure of processes represents the forestry-wood chains in Germany, Austria, Benelux, Poland, Czechia, Slovakia, Slovenia, Hungary, Romania, parts of France, the north of Italy and Switzerland (Figure 2).

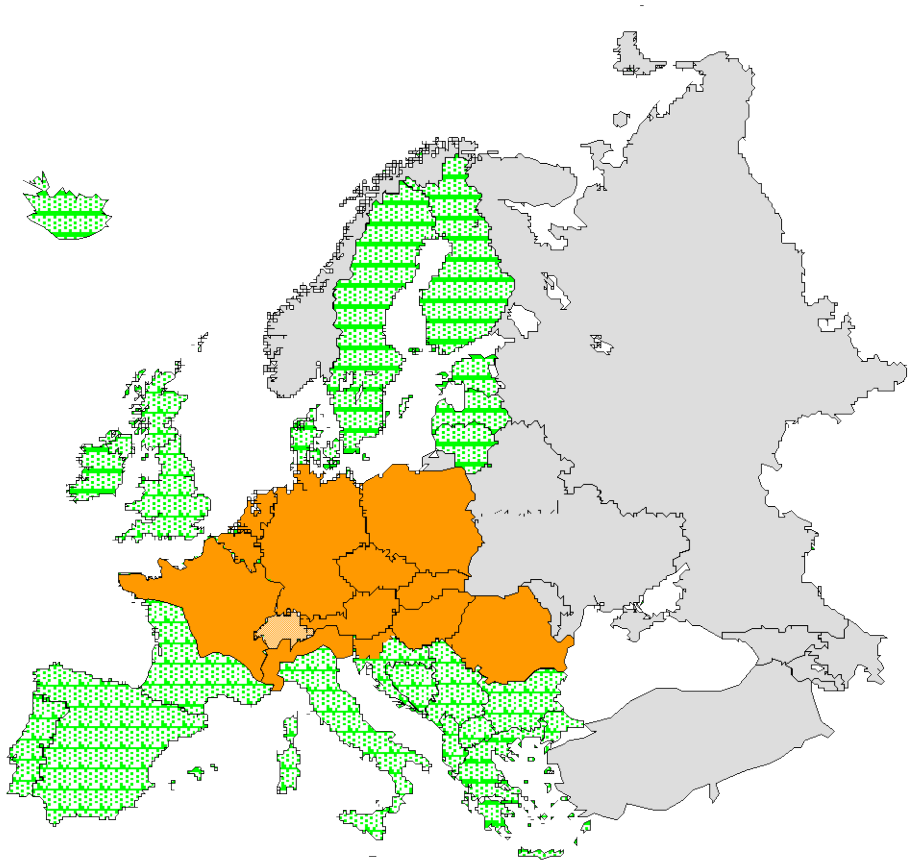

Figure 2: Area in Europe represented by Baden-Württemberg case study

Figure 3 presents a general view on the material flows in the region of Baden-Württemberg. For this case study only the tree species **Norway spruce** (*Picea abies* (L.) Karst.) and **European beech** (*Fagus sylvatica* L.) will be considered as these two species account for more than 2/3 of wood volume produced and processed in Baden-Württemberg. The main **wood industry sectors sawmilling, pulp and paper production, panel production,** and **bio-energy** and successional industries are present in Baden-Württemberg, will be therefore taken into account and included in the case study. As there exist no official statistics for consumption of wooden goods and wood based products specifically for Baden-Württemberg, the following approach will be taken to estimate the **consumption of goods**

from statistical data for Germany as a whole broken down per capita for Baden-Württemberg. There will be material import and export into and out of Baden-Württemberg for roundwood, semi-finished products and end-products. Imports and exports from the other 16 federal states in Germany can not be quantified, also European and overseas imports and exports can only be quantified on an overall German basis. To overcome this problem, **volumes of material in exports and imports in each category will be handled as net-balance**. The volume of material will be derived from known volumes produced in Baden-Württemberg and known volumes consumed. From that difference either a net import or a net export of wood volume in this category will be assumed without differentiation wherefrom or whereto the material comes unless this is known by expert knowledge. Altogether 60-80% of the natural production in the forests, of primary and secondary processing in the wood industry, i.e. wooden products, paper and boards, panels and bio-energy and of the consumption of the produced goods will be described. Consumption of the goods will end either as recycling into the material flow or as incineration of feed-back, though by federal law deposition of organic material in landfills is not allowed any more since June 1, 2005.

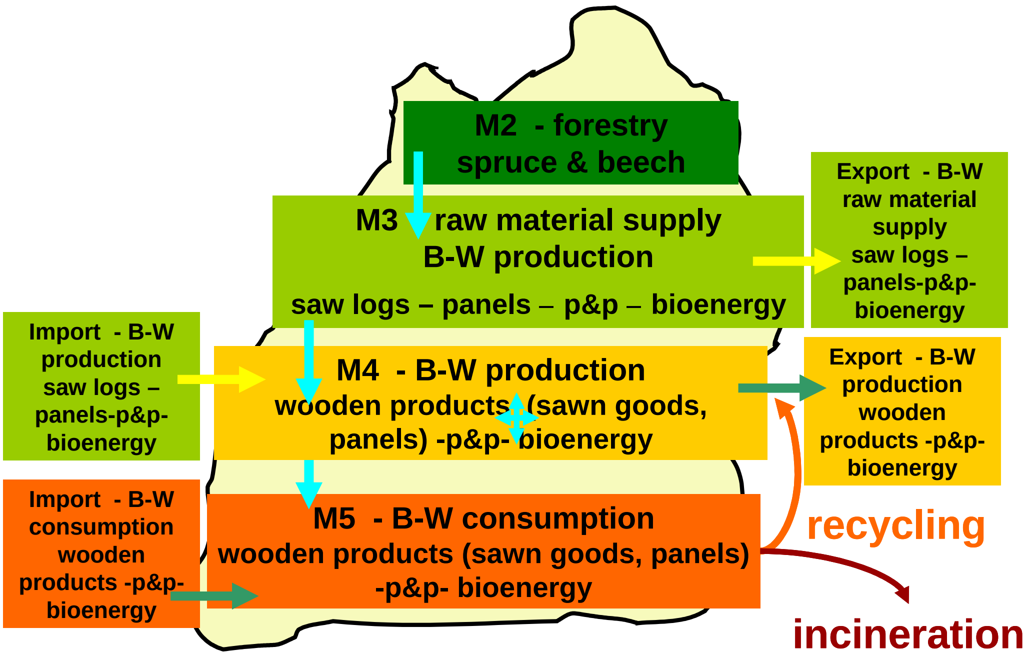

Figure 3: Generalised material flow of wood and products in Baden-Württemberg

3 Definition of the regional case study “Baden-Württemberg”

3.1 Boundaries of the case study Baden-Württemberg, description of the region

AREA, POPULATION

The region in investigation is defined by the political and geographical boundaries of the federal State of Baden-Württemberg, the capital is Stuttgart.

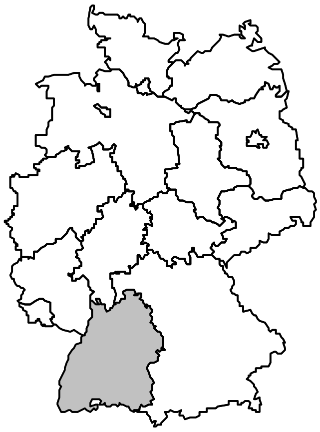

Figure 4: Localisation of Baden-Württemberg within Germany

Baden-Württemberg is characterised by the following attributes:

total area	3.6 mio ha,
forest cover	38.1%
population	10,736 mio inhabitants, on average 300 people/km²
urban population	65%
rural population	35%
forest area	1.4 mio ha
state forest	1 owner
communal forest	1073 owners
private forest	ca. 220.000 owners

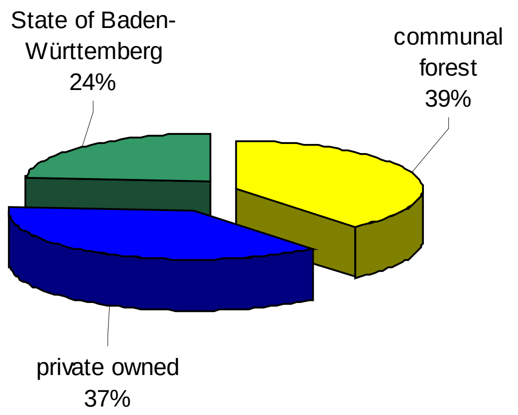

Figure 5: Forest ownership in Baden-Württemberg

WOOD-BASED INDUSTRY

All wood industry sectors relevant, i.e. sawmills, pulp/papermills, panel mills, bio-energy are present in Baden-Württemberg. Table 1 and Table 2 summarise the facilities, employment and economic figures for the different sectors.

Table 1: Number of companies, employees and turnover of the wood-based industry in Baden-Württemberg

	Number of companies	Number of employees	Turnover billion €
Forestry	2.800	19.800	0.557
Saw mills	410	6.000	1.734
Wood based materials industry	50	1.500	0.679
Packaging	19	725	0.142
Furniture	1.487	30.000	3.497
House construction	70	5.000	2.144
Carpentry	2.000	10.000	1.189
Joinery	2.400	30.000	2.800
Miscelleanous	1.400	8.000	0.761
Pulp and paper industry	482	30.275	8.338
Timber retail / trade	370	1.000	1.391
Total	**11.769**	**142.300**	**23.232**

Table 2: Production capacity in Baden-Württemberg (2006)

sawmill softwood >500 000m³	sawmill softwood 50000 - 500000 m³	sawmill softwood hardwood 20000 - 50000 m³	mechanical pulp	chemical pulp	panel production (MDF, particle board)	bio-energy (pellets)
2	16	3	3	2	2	7

Figure 6 shows the location of the sawmilling industry and successional carpentry and joineries. Figure 7 shows the location of the Baden-Württemberg pulp and paper mills. For both sectors of primary processing the largest production capacities are located in areas with good access to large wood resources to ensure their intake for production. Secondary processing such as carpentry in contrast is more scattered distributed in Baden-Württemberg closer to the end-consumer.

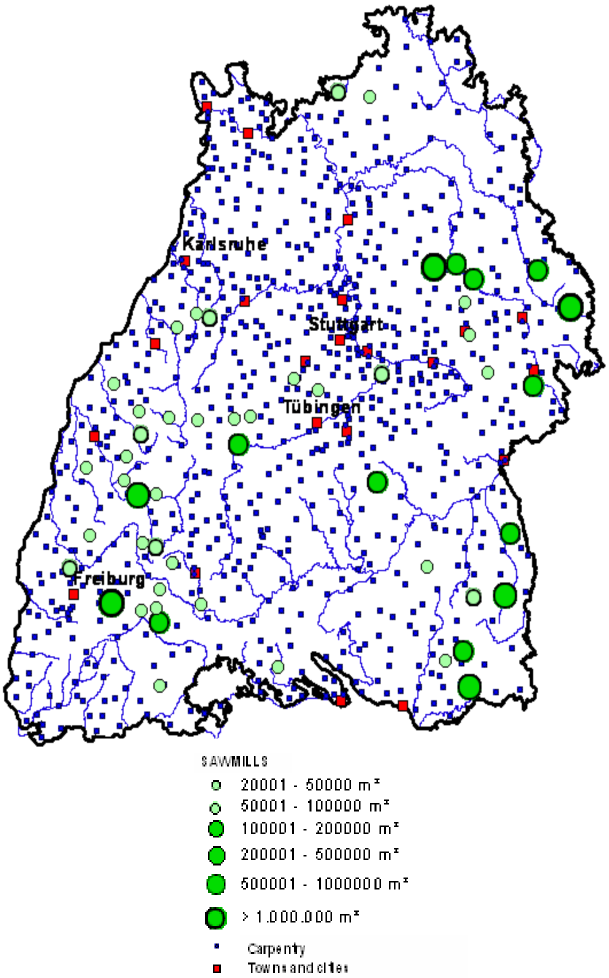

Figure 6: Locations of sawmills and carpentry in Baden-Württemberg

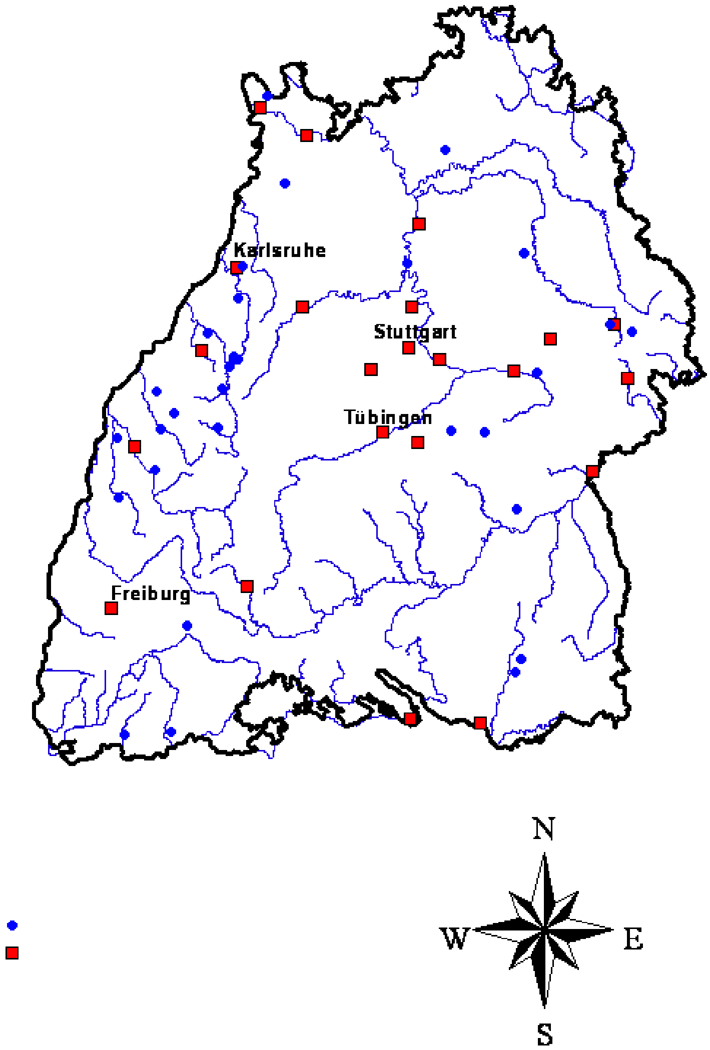

Figure 7: Locations of pulp and paper mills in Baden-Württemberg

3.2 Module 2 - Forest resource and natural production

The case study includes the geographic region of Baden-Wuerttemberg located in south-western Germany as it is defined by its political and geographical boundaries. The total area of this region comprises 3.6 mio ha, out of which approximately 1.4 mio ha (38.1% of the total area) are forested. The forest cover consists of mainly even-aged stands, however within the last decade conversion to more broadleaved tree species and more structured stands is going on. At present the main tree species are Norway spruce (*Picea abies*) with approximately 550,933 ha (39% of all tree species) and European beech (*Fagus sylvatica*) with approximately 288,770 ha (21%), respectively. The mean annual increment (MAI) for these two species is relatively high as assessed by the difference between the second and first NFI in 1987 and 2002. For Norway spruce MAI is 16.7 m^3/ha/year and for European beech 12.9 m^3/ha/year, respectively. The annual harvested volume accounts for 10 100 000 m^3/year. However, beside timber production being the main use of the forest, it provides ecological benefits as well. Around 11% of state area and 18.7% of the forests are classified under Natura 2000.

Within the framework of the case study Baden-Württemberg Module 2 (M2) defined and described processes at different stages of forest production and for various management options. Further, the impact of alternative forest management for Norway spruce and European beech was analysed on wood resources quantity and quality.

Like in the other two EFORWOOD case studies, five forest management alternatives[1] which can be arranged along a gradient of management intensity from non-intervention to intensive stand management were defined. Beside the general approach pursued in each alternative, a corresponding set of silvicultural options was formulated as basic principles. Thus, for each alternative the typical sets of forest operation processes on a stand level could be described for the considered tree species in the Case study. Addressing basic decisions to be met which affect tree species composition, age pattern, stand density and site conditions, these principles reflected the impact of the management alternative on forest ecosystem.

[1] These five forest management alternatives, i.e. “unmanaged forest nature reserve”, “close-to-nature forestry”, “combined objective forestry”, “intensive even-aged forestry” and “short rotation forestry”, are not to be confused with “scenarios” as defined in the EFORWOOD-Project. An infinite number of imaginable futures might be explored for the future of the European forest sector’ scenarios. However, since this is not feasible only a limited number of options for the future can be explored. This option for future development can be called a scenario and will affect the whole Forestry-wood Chain. According to the assumed scenario a shift in the preference among the five forest management alternatives might be expected altering the future balance of stand management practices in a given region.

Forest operation processes implemented in forest management alternatives have an effect on the status and dynamics of processes in forest ecosystems. Since, derived goods as well as services are affected, forest management alternatives have implications on all three dimensions of sustainability. One aim of this task was to simulate the effect of forest management alternatives on selected sustainability indicators by examining the value change in the indicator set induced by the silvicultural treatment.

The analysis of the sustainability impact was based on the forest resource as assessed in the national forest inventories in 1987 and 2002. An improved version of the stand-level simulator W+ (Yue *et al.*, 2008)[2] was applied to estimate the development of considered regional Norway spruce and European beech forest in reference years 2015 and 2025 under alternative forest management approaches (silvicultural treatment regimes). In addition to dendrometric data readily available from simulator standard output, routines for calculating EFORWOOD specific sustainability indicator values based on standard output information were developed. Resulting information derived from alternative treatment regimes was stored in an external database and served for queries to characterize the first link, i.e. the forest management segment (M2) of the Forestry-Wood-Chain within the "EFORWOOD Case Study Baden-Württemberg". Further, this external database allowed to search for optimized treatment regimes with linear programming algorithms for the beech and spruce forest resource under the assumptions specified for the reference futures and scenarios. The corresponding quantified general drivers from EFI-GTM were set as constraints while maximizing net revenue from forest management. Summarized data from the best combination of different corresponding treatment regimes were reported to the general database client, e.g. as input information to M3, and used to report sustainability indicator values by tree species and phase of development (see below).

3.2.1 Detailed information on the forest resource in Baden-Württemberg according to the National Forest Inventories in 1987 (NFI[1]) and 2002 (NFI[2])

The information that is given in the following sub-chapters is based on the following two data sources:

http://www.bundeswaldinventur.de/enid/feed62b1a78c5ab2fbfaf11e9e42911e,0/a9.html

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2 Yue,Ch., Kohnle,U., Hein,S., 2008. Combining Tree- and Stand-Level Models: A New Approach to Growth Prediction. Forest Science 54, 553-566.

http://www.fva-bw.de/indexjs.html?http://www.fva-bw.de/forschung/bui/bwi.html

These sources provide summarized data assessed at the two national forest inventories in 1987 and 2002, respectively. In the following chapters a general characterisation of the forest resource in Baden-Württemberg is given. For detailed analysis in the case study plot level and individual tree data were used. It is to be noticed, that accordingly the more detailed information might deviate from indicated numbers and figures provided in this document.

3.2.2 Forest area

The total area of Baden-Württemberg comprises 3.575.163 ha, out of which approximately 1.362.228 ha (38.1% of the total area) are forested. The forest area of Baden-Württemberg is subdivided into seven growth regions according to different climatic, geological and general site characteristics. Depending on the growth region tree species, forest types and silvicultural management regimes differ with consequences for wood production and the wood-based industry.

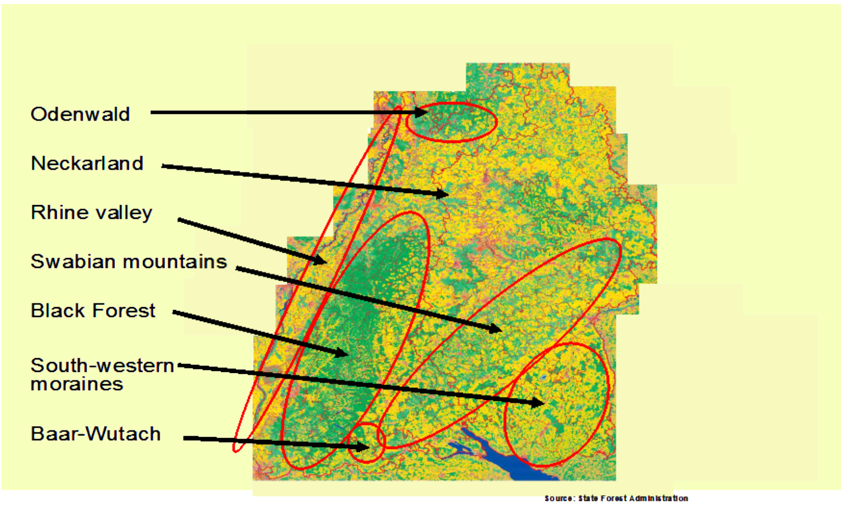

Figure 8: Land use and growth regions in Baden-Württemberg

3.2.3 Species

The proportion of Norway spruce and European beech dominated forests is approximately 57% of the total area. Their share on the total timber stock in Baden-Württemberg is 64% and approximately 66% of the total annual increment (Table 3:; Figure 9).

Table 3: Species area distribution in Baden-Württemberg

[1000 ha]	NFI 1 (1987)		NFI 2 (2002)	
Spruce	573.15	±1.7%	499.2	±1.8%
Fir	103.53	±3.5%	104.51	±3.4%
Dgl	29.73	±5.8%	37.63	±5.2%
Pine	108.36	±3.6%	89.68	±3.7%
Larch	26.07	±4.9%	25.09	±4.9%
Beech	245.38	±2.4%	280.59	±2.2%
Oak	89.55	±3.6%	97.21	±3.3%
other dec.l[1]	100.18	±3.2%	134.43	±2.8%
other dec.s[2]	39.87	±4.8%	54.78	±4.0%
all coniferous	840.83	±1.5%	756.11	±1.5%
all deciduous	474.98	±1.9%	567.01	±1.7%
all tree species	1.315.82	±1.2%	1.323.12	±1.2%

1 other deciduous tree species with a long life expectancy

2 other deciduous tree species with a short life expectancy

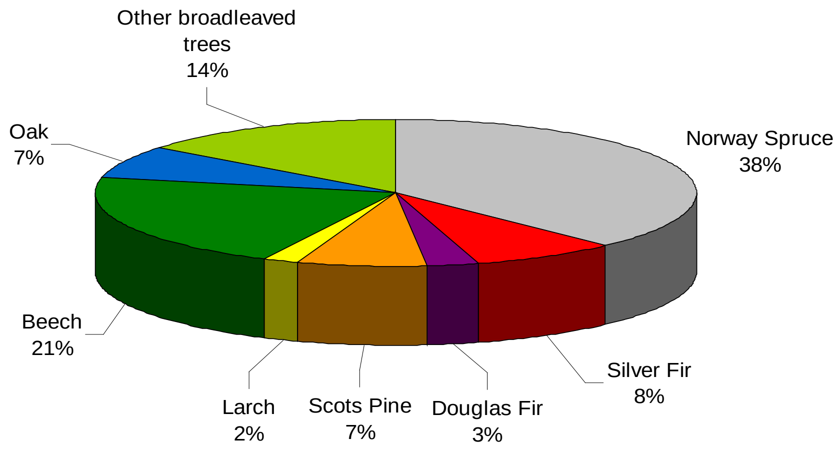

Figure 9: Tree species in Baden-Württemberg of economic relevance

3.2.4 Age classes

When the area is divided in age classes of 20 years it can be seen that 45% of the area stocked with Norway spruce and 70% stocked with European beech in Baden-Württemberg holds trees older than 60 years.

Table 4: ***Forest area by main tree species and tree age class in Baden-Württemberg***

[ha] | [% of tree species area]	Norway spruce		European beech	
≤ 20 years	55.314	11 %	21.675	8 %
21-40 years	108.007	22 %	21.096	8 %
41-60 years	111.068	22 %	41.281	15 %
61-80 years	75.208	15 %	43.452	15 %
81-100 years	75.927	15 %	50.043	18 %
101-120 years	44.106	9 %	45.484	16 %
121-140 years	20.204	4 %	29.454	10 %
141-160 years	5.624	1 %	20.298	7 %
> 160 years	3.739	1 %	7.806	3 %

3.2.5 Productivity

The mean annual increment in Baden-Württemberg over all tree species is 13.7 m^3/year/ha; however the cuttings reach almost the same amount of wood.

Table 5: ***Mean annual increment and cuttings by tree species in Baden-Württemberg***

[m^3 o.b./year/ha]	Increment		Cuttings	
Spruce	16.78	±0.7%	19.41	±1.8%
Fir	16.4	±1.4%	13.39	±3.6%
Dgl	19.66	±2.4%	8.67	±7.5%
Pine	7.93	±2.0%	11.11	±3.3%
Larch	11.88	±2.4%	11.16	±5.1%
Beech	12.9	±0.9%	8.73	±2.8%
Oak	8.43	±1.4%	6.23	±4.0%
other dec.l[1]	9.24	±1.8%	4.49	±4.4%
other dec.s[2]	6.87	±3.9%	5.88	±7.4%
all coniferous	15.6	±0.7%	16.88	±1.6%
all deciduous	10.76	±0.8%	7.08	±2.2%
all tree species	13.7	±0.6%	13.04	±1.3%

[1] other deciduous tree species with a long life expectancy
[2] other deciduous tree species with a short life expectancy

3.2.6 Diameter distributions

The Norway spruce and European beech stands form around 64% of the total growing stock in Baden-Württemberg. About 41% of the volume in Norway spruce and 51% in European beech can be found in trees with a breast height diameter larger than 41 cm.

Table 6: ***Timber stock by tree species and breast height diameter in Baden-Württemberg***

[1000 m^3 o.b] | [% of total standing volume by tree species]	Norway spruce		European beech	
≤ 10 cm	1 319	0.6 %	675	0.7 %
11-20 cm	19 430	9.2 %	8 307	8.4 %
21-30 cm	45 103	21.3 %	16 298	16.4 %
31-40 cm	58 788	27.8 %	23 310	23.5 %
41-50 cm	48 783	23.0 %	23 387	23.6 %
51-60 cm	25 779	12.2 %	16 075	16.2 %
61-70 cm	8 937	4.2 %	6 660	6.7 %
71-80 cm	2 659	1.3 %	2 962	3.0 %
81-90 cm	639	0.3 %	1 033	1.0 %
> 90cm	287	0.1 %	559	0.6 %

3.2.7 Increment

The total volume increment of Norway spruce in Baden-Württemberg is approximately 8 376 576 m^3/year and of European beech 3 619 611 m^3/year. The mean annual increment is 16.78 m^3/year/ha and 13.70 m^3/year/ha, respectively.

3.2.8 Dead wood

The mean amounts of deadwood for Baden-Württemberg are around 19.07 m^3/ha, out of which 10.36m^3/ha are lying on the ground, 1.15 m^3/ha are standing dead trees, 1.85 m^3/ha are standing tree fragments and 5.71 m^3/ha are dead stumpages and roots.

3.2.9 Cuttings

The mean annual cutting of timber stock is 19.41 m³/ha for Norway spruce and 8.73 m³/ha for European beech. Together this accounts for approximately 70.4% of all cut timber in Baden-Württemberg.

Table 7: ***Annual harvested timber volume by tree species and age class in Baden-Württemberg between NFI 1 (1987) and NFI 2 (2002)***

[m^3 o.b. /year/ha]	Norway spruce	European beech
≤ 20 years	2.2	0.3
21-40 years	9.9	4.2
41-60 years	15.5	5.4
61-80 years	18	6.4
81-100 years	21.7	7.9
101-120 years	20.2	8.9
121-140 years	20.9	10.9
141-160 years	17.4	14.9
> 160 years	18.5	12.6

The mean annual cut for Baden-Württemberg during the years 1987-2002 is 9.5 million m^3/year.

3.2.10 Definition of processes in the case study topology: Forest by *Phase of Development*

The development of a stand is classified into four "**Phases of development**" according to the achieved height and diameter growth. For further detail see the deliverable PD2.1.1:

- **Regeneration**

Def.: The act of renewing tree cover by establishing young trees naturally or artificially until the stand reached 2 to 3 m height. (Helms, J. A. 1998. *The Dictionary of Forestry*. Society of American Foresters)

- **Young**

Def.: The time between the point when the stand reached 2 -3 m height and the point it reached 7cm breast height diameter (DBH).

- **Medium**

Def.: The time between the trees reached 7cm DBH and the point it has attained most of its potential height growth.

- **Adult (Mature)**

Def.: The time since the stand has attained most of its potential height growth. (Helms, J. A. 1998. *The Dictionary of Forestry*. Society of American Foresters)

For each development phase **operation process groups** are defined, and **operation processes** are used as subdivisions for these groups, in case there are multiple processes in one group (see table below).

Table 8: Forest area by phase of development in Baden-Württemberg

[ha] | [% of tree species area]	Norway spruce		European beech	
Regeneration and Young[1]	40 292	8.3%	18.360	6.7 %
Medium[2]	153 003	31.7%	154.580	56.9 %
Adult[3]	289 941	60.0%	98.973	36.4 %
Total[4]	483 236	100 %	271.913	100 %

[1] It was not possible to separate the two phases of stand development. At present this class comprises all trees with height >20cm and dbh < 7cm!
[2] Comprises all trees with dbh > 7cm up to a height of 27 to 28 m
[3] All trees with height > 27 to 28 m
[4] Total areas are smaller than indicated above due to different ways of calculation on federal and country level respectively.

3.2.10.1 Processes defined in M2

Process ID in the Client	Process name
1000144	Spruce regeneration
1000145	Development of young spruce
1000146	Development of spruce in medium phase
1000147	Adult spruce development
1000202	Beech regeneration
1000204	Development of young beech
1000205	Development of beech in medium phase
1000208	Development of adult beech

Spruce regeneration (ID: 1000144): Process describes the regeneration of Norway spruce which is the act of renewing tree cover by establishing young trees naturally or artificially until the stand reached 2 to 3 m height. This process can already start under existing stands. Planting is only the case if there is not sufficient natural regeneration. Norway spruce is planted at a spacing of approximately 2 x 3m (~1700 saplings per ha) with additional planting of beech in patches. For 2005 no mechanical weed control around seedlings is considered. Data source for planted and naturally regenerated area is National Forest Inventory (BWI). The output product is the regenerated young stand.

Development of young spruce (ID: 1000145): Process describes the stand development between the point in time when the stand reached 2 –3 m height, but mean breast height diameter is less than 7 cm. During this phase of development pre-commercial thinning is performed twice, i.e. at tree height 2 m a schematic reduction to 1000 – 1500 trees and at tree height 5 m max. 250 spruces are selected and released from any competitors within 3 m radius. Area is taken form National Forest Inventory, but residues have to be estimated according to schematic reductions given above. Output products are forest residues from pre-commercial thinnings and stand in medium phase of development.

Development of spruce in medium phase (ID: 1000146): Process describes the stand development between the point in time trees reached 7cm DBH and the point in time they have attained most of their potential height growth (80% of h_{100}). During this phase of development future crop trees are selected and released by removing competitors in a thinning from above. In repeated thinnings competitors of future crop trees are removed in case they grow into the crown and slow down growth of crop trees. Data source for area and thinnings is National Forest Inventory. Thinnings only include trees, which are taken out of forest. Output products are trees marked to be thinned and remaining stand in adult phase of development.

Adult spruce development (ID: 1000147): Process describes the stand development starting at point in time where stand has attained most of its potential height growth (>80% of h_{100}). During this phase of development trees that reached the production target are harvested. According to the data source the final harvesting system is unknown. Data source for area and harvesting is National Forest Inventory. Harvesting trees only include trees, which are taken out of forest. Output products are trees marked to be harvested.

Beech regeneration (ID: 1000202): Process describes the regeneration of European beech which is the act of renewing tree cover by establishing young trees naturally or artificially until the stand reached 2 to 3 m height. This process can already start under existing stands. Most European beech stands are natural regenerated with planting on the spots where not sufficient regeneration is available. If there is not sufficient natural regeneration, European beech is planted at a spacing of approximately 2 x 1m (>5000 saplings / ha) with additional planting of mixed species in patches (~20%). Areas are taken from Inventory. The output product is the regenerated young stand.

Development of young beech (ID: 1000204): Process describes the stand development between the point in time when the stand reached 2 – 3 m height, but mean breast height diameter is less than 7 cm (dbh). During this phase of development tending is performed in order to remove up to a max. of 500 wulf trees per ha. In continuation of the tending operations 0-1 pre-commercial thinnings are undertaken removing up to a max. of 500 wulf trees per ha in order to promote growth of about 1000 trees with high quality as potential future crop trees. Area is taken from National Forest Inventory, but residues have to be estimated according to schematic reductions given above. Output products are forest residues from tendings and pre-commercial thinnings of stands in medium phase of development.

Development of beech in medium phase (ID: 1000205): Process describes the stand development between the time trees reached 7 cm dbh and the time they have attained most of their potential height growth (80% h_{100}). During this phase of development future crop trees are selected when natural pruning reached desired height and main competitors are removed in thinnings with 5-10 year intervals with max. 80 m^3 per hectare and operation. Data source for area and thinnings is National Forest Inventory. Thinnings only include trees, which are taken out of forest. Output products are trees marked to be thinned and remaining stand in adult phase of development.

Development of adult beech (ID: 1000208): Process describes the stand development starting with the time since the stand has attained most of its potential height growth (>80% h_{100}). During this phase of development thinnings are continued and final harvest starts when trees reached the production target. According to the data source the final harvesting system is unknown. Data source for area and harvesting is National Forest Inventory. Harvesting trees only include trees, which are taken out of forest. Output products are trees marked to be harvested.

Table 9: Interface between M2 and M3 concerning forest area and stem volume reported per process in M2 for 2005

IDChain	Name	IDProcess	ProcessName	Module	Trans - formation -Factor	Forest Area [ha]	Stem Volume [m^3 ha^{-1} o.b.]	TopBranch/ Volume [m^3 ha^{-1} o.b.]
10000001	Baden-Württemberg General Structure Case Study	1000144	Spruce regeneration	2	1	25,257.87	0	n.a.
10000001	Baden-Württemberg General Structure Case Study	1000145	Development of young spruce	2	1	15,163.49	0	6.184967969
10000001	Baden-Württemberg General Structure Case Study	1000146	Development of spruce in medium phase	2	1	278,103	362.46	447.55
10000001	Baden-Württemberg General Structure Case Study	1000147	Adult spruce development	2	1	205,928	605.53	681.36
10000001	Baden-Württemberg General Structure Case Study	1000202	Beech regeneration	2	1	6,830.55	0	n.a
10000001	Baden-Württemberg General Structure Case Study	1000204	Development of young beech	2	1	11,301.76	0	14.40186313
10000001	Baden-Württemberg General Structure Case Study	1000205	Development of beech in medium phase	2	1	98,605	246.73	295.29
10000001	Baden-Württemberg General Structure Case Study	1000208	Development of adult beech	2	1	172,567	451.72	510.04

3.3 Module 3 – Forest to Industry Interactions (allocation, harvesting, transport; millgate)

The wood volume covered by M3 for the case study Baden-Württemberg is 60-80% of wood harvested in the region. Reference year is 2005. According to 2005 harvesting statistics for Baden-Württemberg, total harvested volume was 9.1 mio m³ roundwood under bark (softwood 7.1 mio m³, hardwood 2.0 mio m³). Harvested wood is provided as long logs (poles) and short logs for sawmilling, short logs for board production, mechanical pulping, chemical pulping, and wood for bio-energy production (pellet production, energy chips).

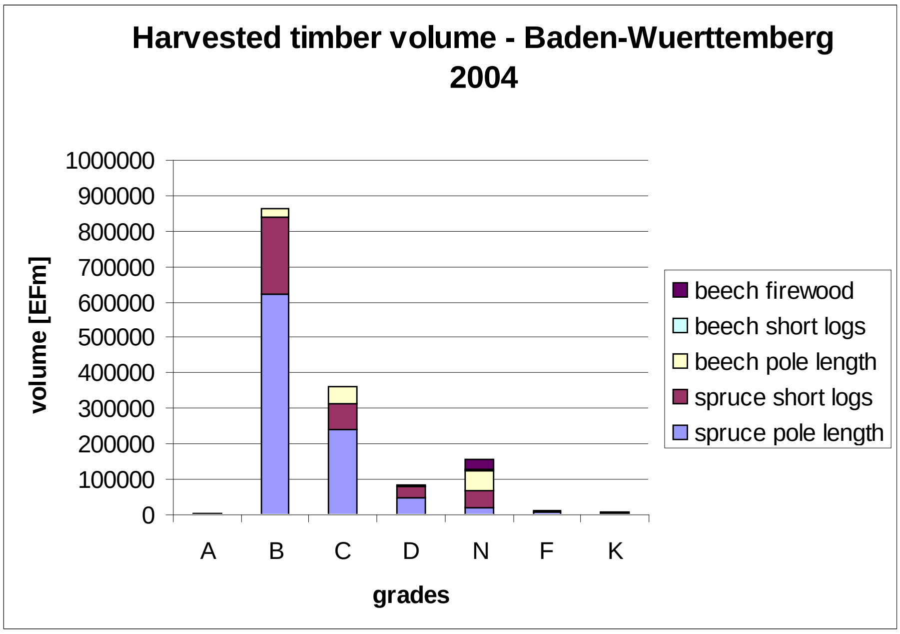

Figure 10: Harvested volume in Baden-Württemberg in 2004 – Quality grade distribution (MLR Baden-Württemberg, 2005)

Table 10: Shares of forest products of tree species (MLR Baden-Württemberg, 2005)

	long and short logs (sawmills)	pulp/paper/panels short logs	bio-energy	other species sawmilling, p&p, boards	total
Spruce (incl. fir, Douglas fir)	80 %	9 %	7 % (incl. pine, larch)	4%	100%
European beech	2%	21%	48% (incl. other hardwoods)	29%	100%

3.3.1 Harvesting/forwarding systems

For Baden-Württemberg over 20 different harvesting and forwarding systems are described in detail (Sauter et al., 2009). Harvesting systems can generally be classified into the three categories: motor-manual, partly mechanised and fully mechanised, and are applicable either to softwood, to hardwood or to both species groups. The decision on the harvesting system depends in general on the diameter of the trees and on the terrain. Related to the decision on the harvesting system is the type of harvested products: the main products of motor-manually felled trees being long logs, the products of mechanised harvesting being short logs for sawmills and pulpwood.

In Baden-Württemberg most of the wood is harvested by thinning operations (approximately 90%), finals cuts are mainly selective. Machines are only operating on skid-roads at distances of 20 or 40 meters, depending on the soil conditions.

For each phase of development, Module 2 reported tree species, number of tree, and for each tree, tree size, volume of wood ready for harvesting, slope, and other required conditions. The appropriate harvesting system was selected accordingly. For purpose of better overview a generalising approach was applied which is described in larger detail in the deliverables 3.2.1 to 3.2.6 produced by partners of workpackage WP 3.2 “Harvesting”. For the case study Baden-Württemberg the relevant harvesting systems are listed in Table 11. .

Table 11: Harvesting systems in Baden-Württemberg

Diameter (breast hight) of harvested trees	slope		
	<= 30% (striproads interval 20/40 m)	30-60% (accessible by road)	>60% (not accessible by road)
<= 35 cm	**harvester/ forwarder** harvester/ forwarder and midfield operations with chainsaws	**Motormanual harvesting, forwarding with skidders**	**Motormanual harvesting, forwarding with cable cranes**
> 35 cm	**Motormanual harvesting, forwarding with skidders**	**Motormanual harvesting, forwarding with skidders**	

* all forest privately owned, < 10h on level terrain was allocated to motormanual felling to account for the realistic harvesting systems

3.3.1.1 Definition of harvesting and forwarding processes

Motor-manual system:

- Felling of selected trees, debranching and topping by chainsaw
- Forwarding of the pole length tree with a skidder to the forest road
- Cutting to saw logs (normally long logs up to 21m long from the lower part of the tree and short logs from the upper part; type and number of saw logs depend on the length of the stem and the customer demands) and pulpwood; measuring and quality classification
- Transport of the long logs by trucks for long timber with cranes to the sawmills (see 3.4 Transport)

<u>Machines</u>

- Medium chainsaw (3.1 – 4.0 kW; bar length 45 cm),
- Skidder with double winch wheel and crane

<u>Products</u>

long logs, short logs, pulpwood, residues for spruce;

long logs, short logs, veneer logs, pulpwood, residues for beech;

Fully mechanised system:

- Precondition: skid-roads at distances of not more than 20 m
- Selective felling, debranching and cutting into short saw logs and pulpwood (depending on quality and on the diameter of the tree) and measuring of the logs by single grip harvester, which is running on skid-roads
- Forwarding and stacking of the logs in piles at forest road side by forwarder
- Transport by trucks for short timber with cranes to the mills (3.4Transport)

<u>Machines</u>

- Medium single grip harvester (101-170 kW, 12-20 t), medium forwarder (10-13 t)

<u>Products</u>

Short logs, pulpwood; residues for spruce and beech

Processor tower yarding (whole tree logging) on very steep terrain (>60%):

Description

- Felling and topping of the trees by chainsaw
- Forwarding as whole trees to the forest road by the yarder
- Debranching and cut to assortments by processor unit

Machines

- medium chainsaw (3,1 – 4,0 kW; bar length 45 cm)
- wheeled tower yarder with mounted processor unit

Products

Short saw logs, pulpwood, residues

3.3.1.2 Definition of processes of fuel wood production

Systems for the production of fuel wood such as split fire wood or forest wood chips are defined as follow-up processes either from the forwarding processes or directly following the felling processes. The processes are not applied in the reference year 2005, but only reference futures and in the bio-energy – scenarios.

Systems for bio-energy production by wood-chipping:

Production of fuel wood from forest residues (tops, branches, off-cuts) was defined for the harvesting alternatives in spruce and beech: flat terrain (<30% slope) as follow-up activity after motor-manual, and fully-mechanised harvesting. The wood for bio-energy include all parts of the tree which are not suitable for saw mill processing or are not allocated to pulpwood or firewood; however applying the bio-energy scenario to the Baden-Württemberg case, the material flow calculated to follow into the bio-energy line changes allocated volumes to firewood and pulpwood assortments.

Description

- State of the Art harvesting systems
- Forwarding of crown material to the forest road by forwarder
- Chipping of the material at roadside in containers
- Transport of the containers to energy plant

Machines

- depending on harvesting system
- medium-sized woodchipper, truck or trailer mounted

Products

sawlogs, pulpwood and/or chips

Systems for fuel wood production by splitting fire wood:

Production of split firewood follows the forwarding processes for softwood and hardwood. It is only applied in the bioenergy scenario.

Description

- input of firewood piled at the roadside
- splitting of the material at roadside in containers
- Transport of the containers to final use

Machines

- medium-sized wood splitter, truck or trailer mounted

Products

split firewood, 30 cm length

3.3.1.3 Processes defined in M3 – harvesting/forwarding/wood for bio-energy

Process ID in the Client	Process name
1000143	Harvesting fully mechanised (Spruce, DBH <= 35 cm; Slope <= 30 %)
1000148	Harvesting motormanual (Spruce, DBH > 35 cm; Slope <= 30 %)
1000149	Harvesting motormanual (Spruce, DBH <= 35 cm, Slope 30 - 60%)
1000150	Harvesting motormanual (Spruce, DBH > 35 cm; Slope 30 - 60%)
1000151	Harvesting motormanual (Spruce, Slope > 60%)
1000210	Harvesting motormanual (Beech, Slope > 60 %)
1000211	Harvesting motormanual (Beech, DBH > 35 cm; Slope <= 30 %)
1000212	Harvesting motormanual (Beech, DBH <= 35 cm; Slope 30 - 60 %)
1000213	Harvesting motormanual (Beech, DBH > 35 cm; Slope 30 - 60 %)
1000214	Harvesting fully mechanized (Beech, DBH <= 35 cm; Slope <= 30 %)
1000531	Forwarding with forwarder (Spruce, DBH <= 35 cm; Slope <= 30 %)
1000532	Skidding (Spruce, DBH <= 35 cm; Slope 30 - 60%)
1000533	Skidding (Spruce, DBH > 35 cm; Slope <= 30 %)
1000570	Skidding (Spruce, DBH > 35 cm, Slope 30 - 60%)
1000571	Forwarding with cable crane + skidding (Spruce, Slope > 60%)
1000613	Forwarding with forwarder (Beech, DBH <= 35 cm; Slope <= 30 %)
1000614	Forwarding with cable crane + skidding (Beech, Slope > 60 %)
1000615	Skidding (Beech, DBH > 35 cm; Slope <= 30 %)
1000616	Skidding (Beech, DBH <= 35 cm; Slope 30 - 60 %)
1000617	Skidding (Beech, DBH > 35 cm; Slope 30 - 60 %)
1000669	Precommercial operations (Spruce)
1000670	Precommercial operations beech
1000728	Harvesting motormanual (Spruce, DBH <= 35 cm, Slope <= 30%)
1000729	Skidding (Spruce, DBH <= 35 cm; Slope <= 30%)
1000736*	Sawing and Splitting of fire wood logs
1000907*	Production of wood chips from the forest

* the processes are not relevant for 2005, but are activated for the reference futures and the scenarios 2015/2025. In 2005 the product shares and split ratios for material flows in the “Database Client” are set to zero = no material flow (0).

3.3.2 Millgate

The processes “Millgate” describe the interface between forest and wood industry. Purpose of the process is measurement and sorting of the roundwood. As no data was available for direct application in this study the following three different systems were assumed which allow different technological advances for the future (reference futures in 20215 and 2025).

Description of the mill gate types:

Mill gate sawmill, short logs:

This millgate type can be found in large sawmills with high roundwood intake and turnover. An automatised measure system is installed which allows online roundwood measuring. The mill gate is defined to work on two shifts with three wheel loaders.

Mill gate sawmill, long logs:

This millgate type can be found in medium sized sawmills with procurement of roundwood to 20m transport length. The roundwood is measured and cut-to-length. The mill gate is defined to work on two shifts.

Mill gate paper mill/panel mill:

This mill gate type is installed both at pulp/paper and panel mill. Measurement of wood volume is based on mass measurement per truckload. The millgate processes are considered the same for both industry sectors.

3.3.2.1 Processes defined in M3 – millgate for 2005

Process ID in the Client	Process name
1000156	Mill gate: roundwood automated measurements and sorting
1000157	Mill gate: roundwood sorting and transporting car
1000158	Particle board mill gate (paper mill type)
1000159	Paper mill gate

3.3.3 Data acquisition and quality

Several data sources were used like official statistics (Eurostat, Statistical Office of Baden-Württemberg), official publications of the Ministry of Rural Affairs in Baden-Württemberg, machine calculations schemes, partners' own calculation models and data from own investigations. Where no information was available, expert opinion was used. For projections into the future and scenario quantification, EFI-GTM results were applied as a basis. The overview of drivers provided by module M1 was used to calculate the general changes in a consistent way among partners. About 50% of the data in M3 2005 is considered of high quality, 29% of medium and 21% of low quality. A lower quality level must be assumed for the data reported for the reference futures and scenarios. This is a consequence from the higher uncertainty due to the combination and aggregation of several assumptions into the projections. Data present in the Eforwood Database Client must therefore be used with care since many compromises and assumptions lie behind the numbers.

3.4 Transport processes in Modules M3/M4/M5

For calculation of the indicator values of the transport processes in the base year 2005 the "TRANSPORT TOOL" (vrs.2) was used for all transport processes except for transport of paper products in M5 (INNVENTIA). The details on use of the tool are described in Deliverable 3.3.4. The following assumptions were applied for parameterisation of the tool.

In Baden-Württemberg and all over Germany, there are three main transport modes (and combinations thereof, named "combined transport") in operation for forestry and wood industry: road transport by truck, rail transport by train and water transport by ship. Cost effectiveness for those modes depends on the volume and largely on the distance. The following distances represent approximate boundaries for that (Smaltschinski, 2007; expert opinion): road < 150 km, rail > 250 km and water > 500 km. The scope of the figures is in line with results from studies by Bodelschwingh (2005), Hecker (2003), Odenthal-Kahabka (2005) and Wegener (2004).

Anyhow, similar to the EU case study, the system boundaries were set at the harbours in Baden-Württemberg which means that the transportation from and to the harbour is considered, but not the transportation from and to the harbour outside this region (see PD 3.3.4). There is only one inland waterway harbour in BW (Hedden 2009: 82).

To fulfil the requirements of covering between 60 and 80% of total wood flow it is possible only to calculate indicator values in the mode "road transport" as this is the most typically transport mode for roundwood in Baden-Württemberg. According to Borcherding (2007) more than 80% of the timber transport is done via truck in Germany. Wegener et al. (2004) come to the conclusion that about 87% of all roundwood in South Germany is transported by truck.

The following assortments of roundwood are transported: spruce and beech long-logs, short logs, pulpwood, fire wood logs, large dimension timber, wood chips from forest and plantation.

The main wood transport systems for wood transport, freight equipments, maximum gross vehicle weights in tonnes etc. are outlined in the project deliverables PD 3.3.2 “Identification of existing transport methods and alternative methods or new approaches with data about costs, labour input and energy consumption” and in the annex of PD 0.0.16 “Manual for data collection for Regional and European cases”. The methodology which was used in the transport tool itself as well as information about the data provided for each vehicle and countries covered by the tool are described in detail in the project deliverable PD 3.3.4 “Data collection of transport processes to ToSIA at case study and EU level” and PD 3.3.6 “Stratified partial model on transport”.

Transport in different countries or regions may involve different parameters as e.g. distances, modes, vehicles, loading rate, empty-backhaulage etc. The following regulations apply for road transport according to the German road traffic regulations: maximum load 40t; maximum width 2.55 / 3m for agricultural or forest goods; maximum height: 4m (incl. load and vehicle); maximum length 20,75m (incl. trailers) (§22 STVO). Table 12 shows assumed conditions and parameters.

Assumptions for transport in M4:

In 2005, there is no use of biofuels. The reasoning behind is that trucks need a redesign of there motors in order to be able to drive with biofuels, and that is very expensive for whole fleets. Therefore, in the indicator calculation energy use of fossil fuels is 100% in 2005.

All M4 transport processes are carried out in road mode, as the farthest distance is 162 km and therewith only in the borderline of train transport profitable, at least for the calculation of 2005 data.

Wages for men and women differ according to a study by IAB 04/2005 in machine operating sectors which states that women get 79.2% of an average man's wage with the same occupation. This value is used in the indicator calculation.

According to branch statistics of 2006 in transport operations 10861 accidents happened, thereof 813 with non-fatal and 63 with fatal injuries. For occupational diseases no figures exist.

Fuel consumption of transport of secondary wood products are only carried out in normal road mode and thus lighter truck without crane are used and the fuel consumption is 40 l/100 km, instead of 45 l/100 km as it is in the heavier duty timber transport from the forest.

Table 12: Transport parameters considered for the case study Baden-Württemberg

Type of product	Transport systems	Distance	Backhaulage [%]	Pay load [t]
Short logs	Tractor + semi-trailer 5 axles with crane	100 km within BW; 200 km outside BW (export)	48	23.4
Sawlogs (long)	Tractor + long-load dolly 5 axles with crane	depending on mill size (small -40 km; medium -65 km; large 75 km)	42	20
Pulpwood	Tractor + semi-trailer 5 axles with crane	93 km (400 km im-/export)	48	23.8
Large Dimension Timber	Tractor + long-load dolly 5 axles with crane	73 km	42	23.8
Wood chips	Solid bulk 5 axles	25 km; (50 km from plantation)	0	45-90 m³ loose
Saw dust		162 km	50	18,9
Sawn timber, panels, other final product		see resp. distance above	50	30
Pellets		162 km	50	18,9

3.4.1.1 Processes defined in M3 – Transport

Process ID in the Client	Process name
1000152	Transport of spruce long logs
1000153	Transport of spruce short logs
1000154	Transport of beech pulpwood
1000155	Transport of LDT
1000220	Transport of beech short logs
1000222	Transport of beech long logs
1000224	Transport of veneer logs
1000225	Transport of beech fire wood logs
1000255	Transport of imported kraft pulp
1000575	Transport of spruce pulpwood
1000730	Transport of spruce fire wood logs
1000750	Transport of imported beech pulpwood
1000757	Transport of exported spruce pulpwood
continue:	
1000758	Transport of exported beech long logs
1000759	Transport of exported beech pulpwood
1000760	Transport of exported beech short logs
1000908	Transport of spruce wood chips
1000909	Transport of beech wood chips
1000903*	Transport of wood residues
1000911*	Transport of wood chips from short term plantation

* the processes are not relevant for 2005, but are activated in the reference futures and the scenarios 2015/2025. In 2005 the volume flow trough these processes set to zero (0).

3.4.1.2 Processes defined in M4 – Transport

Process ID in the Client	Process name
1000166	Transport of softwood sawn timber
1000167	Transport of hardwood sawn timber
1000168	Transport of chips
1000169	Transport of saw dust
1000170	Transport of particle board
1000635	Transport of furniture components
1000688	Transport of imported OSB board

3.4.1.3 Processes defined in M5 – Transport

Process ID in the Client	Process name
1000618	Transport of construction elements
1000638	Transport of furniture to final destination
1000637	Transport of furniture to retail
1000627	Transport of garden/outdoor to final destination
1000626	Transport of garden/outdoor to retail
1000751	Transport of imported construction elements
1000753	Transport of imported furniture to retail
1000625	Transport of imported garden / outdoor
1000752	Transport of imported joinery
1000630	Transport of imported packaging
1000619	Transport of joinery
1000632	Transport of packaging to final destination
continue:	
1000631	Transport of packaging to retail
1000643	Transport of used wood
1000272	Transport of carton board boxes to industry user
1000258	Transport of carton board materials
1000280	Transport of collected used paper
1000606	Transport of corrugated boxes to industry user
1000526	Transport of exported magazine paper
1000523	Transport of exported magazines
1000275	Transport of filled carton board boxes
1000609	Transport of filled corrugated boxes to industry user
1000608	Transport of filled corrugated boxes to retail
1000590	Transport of fine paper to user
1000603	Transport of imported books
1000604	Transport of imported corrugated board materials
1000586	Transport of imported fine paper (woodfree)
1000518	Transport of magazine paper
1000520	Transport of magazines to store
1000514	Transport of newspapers to store
1000509	Transport of newsprint

3.5 Modules 4 and 5 - Production and consumption

For 2005, production and demand of raw wood for the different sectors of the wood industry in Baden-Württemberg summed up as stated below [all numbers in roundwood equivalents (r)]:

roundwood equivalent [m³ (r)]	production	consumption	product equivalent
sawlogs and veneer(softwood/hardwood)	7.3 mio	8.78 mio	5.22 mio (assuming 60% yield
pulpwood (pulp/paper/panels)	1.2 mio	2.94 mio 1.84 mio pulpwood 1.1 mio sawmill chips	
		1.62 mio	
energy wood firewood forest residues chips/hog fuel	1.7 mio 0.66 mio 0.91 mio 0.15 mio	3.03 mio (from forest resources and sawmilling by-products)	

3.5.1 M4/5 – Fibre products chains

Production of paper and board grades considered by the M4 consortium for the Baden-Württemberg regional case sums up to 2.87 mio t. The details are given below.

<u>Production volumes for paper & board grades produced in Baden-Württemberg in 2005</u>

- 1a Newsprint paper 357 000 t
- 1 b Magazine paper 1 515 000 t
- 1c Fine paper 36 000 t
- 2a Corrugated board 283 000 t
- 2b Carton board 682 000 t

To cover 60-80/% of the production of pulp and paper products in Baden-Württemberg, the case study will consider production of the following products:

- 1a Newsprint paper
- 1 b Magazine paper
- 2b Carton board

To produce these products model mills are considered which are described in technical details in PD 4.1.7 provided by Module M4.

For production of the different paper grades in the specific mill types the following material input is necessary:

1. Integrated newsprint:	100% DIP
2. Magazine paper:	10% DIP, 35% bleached SW kraft pulp, 55% mech. pulp (PGW), NOTE: coated 40% minerals
3. Fine paper:	100% kraft pulp (SW: HW = app. 1:2), NOTE: coated 45% minerals
4. Corrugated board:	100% RP
5. Cartonboard:	50% RP, 30% DIP, 20% SW kraft pulp, NOTE: 10% minerals

<u>Input of raw material for the fibre products chains in 2005 sums up to:</u>

Softwood (SW): 2.37 million tones of softwood

- 0.71 million tones of SW chips
- 1.66 million tones of SW logs

Hardwood (HW): 0.04 million tones of hardwood

- 0.012 million tones of HW chips
- 0.028 million tones of HW logs

Deinked Paper (DIP): 0.71 million tones of DIP

Recycled Paper (RP): 0.60 million tones of RP

- 1.45 million tones of recycled paper

Production of pulp in 2005:

- 3.4 mio t mechanical pulp

Consumption of paper & board grades in Baden-Württemberg 2005 (CEPI, 2007):

- 1a Newsprint paper 334 000 t;
- 1 b Magazine paper 233 000 t;
- 1c Fine paper 265 000 t;
- 1d uncoated woodfree & coated woodfree paper 534 000 t;
- 2a Corrugated board 525 000 t;
- 2b Carton board & other paper & board for packaging 342 000 t

Share of total consumption of fibre products (CEPI, 2007):

- 1a 13% (Newsprint)
- 1a+1c > 19% (Uncoated mechanical and coated mechanical)
- 2a 20% (Corrugated board)
- 2b+2c 13% (Cartonboard & other paper & board for packaging)

Total > 65%

- 1d < 20% Uncoated woodfree & Coated woodfree

Total 85%

Recycling:

In 2005, 1.72 mio t of recycled paper was available in Baden-Württemberg. The recycling rate for paper in Baden-Württemberg is increasing over the last decades and is reported as 77% for 2005. However, as the approach for calculations in Tosia required fixed material volumes at defined stages the recycling rate was agreed to be flexible in order to feed the required amount of fibres into the fibre production processes. A recycling rate of ~48% was derived for 2005 with slight variation for the reference futures and the bio-energy scenario.

The processes defined for fibre product production are described in detail in deliverable 4.1.9. The approach followed to define and characterise consumption processes for the fibre products chains are described in further detailed detail in deliverable 5.2.10

Import and export of fibre products

		Import	Export
1a	Newsprint paper		-23000
1 b	Magazine paper		-1282000
1c	Fine paper	229000	
1d	uncoated woodfree & coated woodfree paper	534000	
2a	Corrugated board	242000	
2b	Carton board & other paper & board for packaging		-340000

3.5.1.1 Processes defined in M4/M5 – fibre product processes

M4

Process ID in the Client	Process name
1000250	Cartonboard Model Mill
1000252	Integrated Newsprint Model Mill
1000254	Integrated Magazine Paper Mill

M5

1000504	Carton board boxes as packaging material at industry user
1000611	Corrugated boxes as packaging material at industry
1000610	Corrugated boxes as packaging material at retail
1000521	Distribution of magazines to home/office
1000515	Distribution of newspapers to home/office
1000273	Filling of carton board boxes
1000607	Filling of corrugated boxes
1000596	Printing - use
1000592	Printing of books
1000519	Printing of magazines
1000510	Printing of newspapers
1000260	Production of carton board boxes
1000605	Production of corrugated boxes

continue:

1000516	Reading / information use
1000594	Reading /information use
1000527	Reading /information use (magazines)
1000277	Separate collection and sorting of carton board boxes
1000612	Separate collection and sorting of corrugated board
1000597	Separate collectioon and sorting of fine paper
1000517	Separate collection and sorting of newsprint
1000529	Separate collection and sorting of the magazine paper
1000276	Use of carton board boxes

3.5.1.2 Data acquisition and quality

M5

It was very difficult to obtain data for the "consumption processes" of fibre products (M5 responsibility), partly because of the high level of aggregation. For example, a process such as "printing" had to represent several different techniques. Also the type of processes such as "filling boxes" are unspecific in describing what it is that is filled, it could be anything from building material to food etc.

The data inserted in the model must therefore be used with care since many compromises and assumptions lie behind the numbers.

3.5.2 M4/5 – Wooden products and panels

The wooden products (primary and secondary conversion) and panel chains considered in Module 4 "Production" are the following for the Baden-Württemberg case study:

- Solid-wood construction
- Solid-wood joinery
- Solid-wood furniture
- Panel products

For consumption in Baden-Württemberg the following product groups were considered:

- wooden products, panels >>> house construction
- furniture use

The material stream followed consumption through all stages from delivery to the construction and use, destruction, recycling and final incineration. Recycling of material was feed into panel production.

Input of raw material for the wooden products chains in 2005 (source: VDS Baden-Württemberg, personal communication)

8.73 mio m^3 (r) roundwood

(8,5 mio m^3 conifers (>> 91% spruce = 7.74 mio m^3 u.b);

0.23 m^3 mio hardwood logs (>> 67% beech = 0.15 mio m^3 u.b.))

Production volumes for sawn timber products and by-products produced in Baden-Württemberg in 2005 (primary conversion) for the total production (source:ZMP statistics, 2006; Baden-Württemberg Statistics Office, report 2005) [Production figures solely for spruce/fir and beech are given in bold]:

- 5.22 mio m^3 sawn timber (5.08 mio m^3 softwood lumber (= **4.62 mio m^3 spruce**) ;
0.14 mio m^3 hardwood lumber (= **0.10 mio m^3 beech**))
1.58 mio m^3 (r) chips (=**1.43 mio m^3** (r) chips from spruce and beech)
- 0.92 mio m^3 (r) saw dust (=**0.83 mio m^3** (r) saw dust from spruce and beech)
- 0.69 mio m^3 (r) off-cuts; edgings (=**0.62 mio m^3** (r) off-cuts from spruce and beech)
- 0.05 mio m^3 (r) miscellaneous (=**0.41 mio m^3** (r) miscellaneous from spruce and beech)
- 0.27 mio m^3 (r) own requirements (=**0.24 mio m^3** (r) own requirement/energy from spruce and beech)

Input of raw material for panel production chains (particle board) in 2005 (source: VHI Verband für Holzwerkstoffe, personal communication; Ochs et al. 2007):

- pulpwood: 0.27 mio m^3 (r)
- by-products: 1.10 mio m^3 (r)
- scrap wood: 0.237 mio m^3 (r)

Production volume for panels produced in Baden-Württemberg in 2005 (conversion rate input to output product = 0.67 according to NRW Cluster Studie, 2002, 1. Absatzstufe):

- 1.12 mio m^3

Table 13: Production volumes for wooden products from spruce/fir and beech in Baden-Württemberg in 2005 (Baden-Württemberg Statistics Office, report 2005)

Product group		Production volume
sawn timber (spruce) (construction timber solid wood, solid wood boards solid wood joists, solid floor boards cladding, decking, engineered wood joist glulam, solid wood components finger jointed components	Primary conversion, secondary conversion	4.62 mio m³ (= 5.22 mio x 0.91 [91% spruce of total softwood production])
Sawn products (beech)	Primary conversion	0.1 mio m³
external & internal wall floor system roof systems	Secondary manufacturing	consumption of ~ 5 mio m³ timber
windows doors	Secondary manufacturing	606494 pieces
furniture components	Secondary manufacturing	
panel production	Primary processing	1.12 mio
furniture	Secondary manufacturing	

Consumption of wooden products in Baden-Wuerttemberg 2005 (reference)

- wooden products>>> house construction
- packaging
- furniture
- gardening/outdoor

Table 14: Production figures for spruce and beech in Baden-Württemberg (2005)

Material Flow in Baden-Wuerttemberg

Material	MC [%]	Total Volume m3	Total Value [1000 €]	Units	Value per cum [€]	Loading Coefficent	Load per Lorry [m3]	Number of Lorries	Average distance [km]	Return Load	Total Lorry km	Comment	Data Quality
Primary Production													
SAWMILLS													
INPUT													
Spruce/Fir calc	80%	6,496,630					20	324,831	124	NO	80,233,378	share is calculated with share of grown trees in BW	Statistisches Landesamt BW
Beech calc	80%	110,983					20	5,549	124	NO	1,370,644	share is calculated with share of grown trees in BW	Statistisches Landesamt BW
OUTPUT													
Main Products													
Engineered Spruce/Fir products	15%	646,725	162,612		251	60%	41	15,945	162	YES	2,575,099	engineered refers to end-jointed, planed, sanded etc. (The group does not differenciate between softwood species, the share was calculated by the	Statistisches Landesamt BW
Plain Spruce/Fir products	15%	3,413,669	528,216		155	60%	41	84,163	162	YES	13,592,395	only sawn products	Statistisches Landesamt BW
Plain Beech Products	15%	69,365	16,677		240	60%	41	1,710	162	YES	276,193	only sawn (The group does not differenciate between hardwood species, the share was calculated by the amount of wood growing in BW	Statistisches Landesamt BW
By - Products													
Spruce/Fir total		1,941,552										Volume is based on log volume	Statistisches Landesamt BW
Wood chips	30%	873,698				80%	54	16,156	162	YES	2,609,140	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Saw dust	15%	509,657				80%	54	9,424	162	YES	1,521,998	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Shavings	80%	152,412				80%	54	2,818	162	YES	455,150	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Bark	80%	300,941				80%	54	5,565	162	YES	898,704	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Trimmings	80%	8,252				80%	54	153	162	YES	24,642	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Roundwood sale	80%	100,475				60%	41	2,477	162	YES	400,068	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Beech total		715,860										Volume is based on log volume	Statistisches Landesamt BW
Wood chips	60%	322,137				80%	54	5,957	162	YES	962,003	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Saw dust	15%	187,913				80%	54	3,475	162	YES	561,168	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Shavings	80%	56,195				80%	54	1,039	162	YES	167,816	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Bark	80%	110,958				80%	54	2,052	162	YES	331,357	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Trimmings	80%	3,042				80%	54	56	162	YES	9,086	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Roundwood sale	80%	37,046				60%	41	913	162	YES	147,507	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Secondary Production													
Panel Production													
INPUT													
Pulpwood	80%	270,000				60%	41	6,657	95	YES	632,396		Statistisches Landesamt BW
By-Products	60%	660,000				80%	54	12,204	95	YES	1,159,393	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Scrap wood	15%	237,000				80%	54	4,382	95	YES	416,328	MC are assumptions, Volume is based on log Volume	Statistisches Landesamt BW
Furniture Production													
OUTPUT													
Chairs			168,960	547,898		40%	27						Statistisches Landesamt BW
Office Furniture			363,855	620,062		40%	27						Statistisches Landesamt BW
Other Furniture			464,753	246,926		40%	27						Statistisches Landesamt BW
IMPORT AND EXPORT													
Import of Sawn Timber to BW		2,955,619	656,700			60%	41	72,870		YES		the Volume is guessed by taking the average price of sawn wood produced in BW	Statistisches Landesamt BW
Export of Sawn Timber from BW		3,493,455	776,200			60%	41	86,131		YES			Statistisches Landesamt BW
Import Furniture to BW			1,999,600			40%	27						Statistisches Landesamt BW
Export of Furniture from BW			2,121,200			40%	27						Statistisches Landesamt BW
TOTAL											108,344,465		

To reflect on the heterogeneity of the sawmilling and manufacturing industry, the following approach was applied in accordance with the generalised model mill approach as described by M4:

- softwood sawmills: large (>150.000 m^3), medium (50.000<x<150.000m^3), small (< 50.000m^3]
- hardwood sawmill
- joinery production: industrial production enterprises, manufacturing enterprises (small and micro-enterprises)
- furniture production: industrial production enterprises, manufacturing enterprises (small and micro-enterprises)
- panel production (data provided for panel production represent the production of particle board of particle board

A description of the sawmill types, panel production and manufacturing processes in technical details are described in PD 4.1.7 and D 4.1.9 provided by Module M4. The approach followed to define and characterise consumption processes for the solid wood products chains are described in further detail in deliverable 5.2.10.

3.5.2.1 Processes defined in M4/M5 – Wood products chains

M4

Process ID in the Client	Process name
1000160	Softwood saw mill - LARGE
1000161	Softwood saw mill - MEDIUM
1000162	Softwood saw mill - SMALL
1000164	Hardwood saw mill - SMALL
1000165	Particle board mill
1000175	Industrial production of construction elements
1000176	Manufacturing of construction elements
1000177	Industrial production of joinery
1000178	Manufacturing of joinery
1000179	Industrial production of furniture components
1000180	Manufacturing of furniture
1000636	Furniture production

M5

Process ID in the Client	Process name
1000622	House construction
1000623	Use of house
1000624	Demolition of house
1000628	Use of garden/outdoor
1000629	Demolition of garden/outdoor
1000633	Use of packaging
1000634	Demolition of packaging
1000639	Use of furniture
1000640	Demolition of furniture

3.5.2.2 Data acquisition and quality

M4

The data sources reported in PD 4.1.8 were the most important data sources in the solid wood products chain as was expected. The number of production sites and different technologies used at mills made it difficult to find reliable data for the model mills. A lack of available data from high quality sources made data collection difficult and a large number of assumptions had to be made as discussed in D 4.1.11. Background data compiled by M1, including EFI-GTM runs, were widely used as a basis when collecting data for reference futures and scenarios. Also expert guesses and opinions were needed to some extent. As with any large scale project, obtaining high quality statistics was an area of great difficulty within EFORWOOD. Any inaccuracies in the base year data can lead to far greater inaccuracies in the future scenarios.

M5

Deliverable 5.2.10 describes the approaches and difficulties for data collection in large detail. In general it was found difficult to collect data for the processes in M5 as the level of aggregation was too high. For retail no data or study exist allowing the estimation of indicators related to retail processes, so no data were collected for these processes.

3.5.3 M4/5 – Bio-energy from wooden resources

The total energy production from biomass resources grew 25 % in Baden-Württemberg between 2004 and 2005 and was 32.652 TJ and 40.971 TJ[3] respectively (primary energy). In 2004 this represented 2 % of the primary energy consumption in the region. In year 2005 the production of electricity from biomass accounted for 731 GWh (1.952 GWh primary energy, conversion factor 0,374). The total production of heat from biomass was 9.429 GWh. Heat was produced in CHP plants, district heating plants and with small scale wood heating device. The last group consists of pellet ovens (24%) and traditional small scale furnaces (75 %).

The biomass resources used for energy production in Baden-Württemberg are listed in Table 15.

Table 15: Solid biofuel utilisation in Baden-Württemberg. The distribution of different sources of biomass for different plant size classes. (Ochs et al. 2007)

	Plant size class			
Solid biofuel utilization, %	<10000 t	10000-49000 t	50000-99000 t	>= 100000 t
Forest residues [%]	13	11	9	**8**
Sawmill industry by-products [%]	26	17	13	**12**
Wood residues (industry) [%]	44	22	17	**6**
Other biomass [%]	9	17	14	**25**
Forest wood (industrial) [%]	3	2	3	**3**
refuse derived, recycled wood [%]	5	31	44	**46**
total	100	100	100	**100**

Table 16: Biomass plants in Baden-Württemberg (publicly funded) (Forest State Service 2007)

	Plant size class			Total
	< 0,5 MW	0,5 – 1 MW	> 1 MW	
Heat production capacity, MW	41,8	36,2	68,9	146,9
Number of plants	133	48	25	206
Average size, MW	0,3	0,8	2,8	0,7

[3] Umweltministerium (2007)

Production of bio-energy from wooden resources in Baden-Württemberg in 2005 summed up to 3.03 mio m³ roundwood equivalent without bark and recycling material. The material input in the bio-energy chains is related to the wooden products and panel chains and to the fibre products chains. The balance in material is calculated in such a way that the net-balance over all chains equals 0, i.e. all material not required in non-energetic utilisation or recycling will be fed into energy production.

from primary production:

- 0.66 mio m³ (r) firewood
- 0.91 mio m³ (r) forest residues (10% of harvested timber volume)
- 0.15 mio m³ (r) forest chips/hog fuel

from primary conversion

- 0.02 mio m³ (r) saw dust for pellet production
- 0.28 mio m³ (r) saw dust for other bio-energy production and other by-products (roundwood equivalents)
- 0.69 mio m³ (r) cut-off, edging
- 0.05 mio m³ (r) miscellanous
- 0.27 mio m³ (r) own requirement in industry

other sources:

- 0.14 mio m³ (r) bark (Wolf 2005)
- 0,64 mio t atro used wood (Wolf 2005)
- 0.513 mio recovered paper (difference to 2.233 mio t consumed paper and 1.72 mio t recycled paper)

Bioenergy consumption

Error! Reference source not found. shows the bio-energy balance for Baden-Württemberg in 2004. Consumption is broken down to the relevant NACE classification of production processes. The energy volume presented here summarises all solid biomass, not only biomass from wooden resources.

Table 17 Primary energy balance and consumption of bio-energy in Baden-Württemberg (2004); [TJ]

	Unit	Renewables
Primary energy utilisation, (2 % of total primary energy utilisation)	1000 TJ	32,7
Net production	1000 TJ	17,1
Electricity from biomass	%	9
CHP from biomass	%	24
Industrial heat from biomass	%	17
Heat from biomass	%	19
Other renewables like wind and solar	%	32
End use	1000 TJ	15,6
Manufacturing sector *Manufacturing wood and wood products 3,8 TJ (25%)* *Manufacturing pulp, paper and paperboard 5,1 TJ (33%)* *Manufacturing furniture 0,5 TJ (3 %)* *Other manufacturing sectors (9 %)*	%	70
Road traffic	%	13
Private households, other sectors	%	17

Wood pellet consumption Baden-Wuerttemberg including imports :

62700 t

calculation:

330 000 t pellets required in 2005 (all Germany) (VPED, 2008)

255 200 t pellets produced in 2005 (Germany) (VPED, 2008)

19% of all pellet heating systems installed in Baden-Württemberg (VPED, 2008)

>>>>> 62700 t pellets consumed in Baden-Württemberg

fuel wood consumption Baden-Württemberg :

1570000 m³ (r)

Error! Reference source not found. shows the identified channels and links for bio-energy production for Baden-Württemberg.

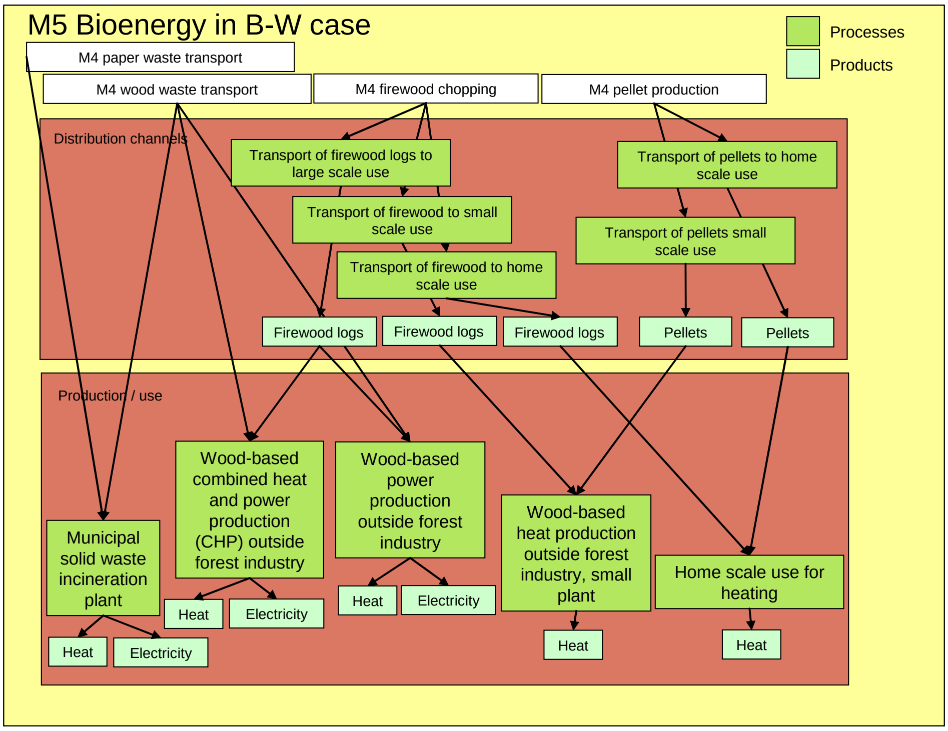

Figure 11 Bioenergy chains identified in Baden-Württemberg (Sources: IEA Energy Statistics and Pöyry Database)

The following M5 bio-energy processes are modelled in ToSIA:

Home scale use for heating

This process includes both use of wood pellets and use of firewood logs in households. Wood pellets are delivered to houses as bulk or in large sacks. They are usually ordered from a retailer, but bulk pellets are delivered directly from plant/storage. Pellets are used in central heating (pellet burners) or as additional source of heat in houses heated with electricity (pellet stoves). Burning process produces 0.4 % ash as residue. It is usually utilised or disposed within household waste. In 2005 pellets were minor part of wood-based household heating and the major source was firewood in logs.

Wood-based heat production outside forest industry, small plant

In addition to households, wood pellets and firewood logs are also used in small heating plants, e.g. schools and hospitals. Plants use only bulk pellets, which are transported by truck or ship to buyers' storage.

Wood-based combined heat and power production (CHP) outside forest industry

Combined heat and power production (CHP), also called cogeneration, is an energy conversion process where electricity and useful heat are produced simultaneously in a single process. Electricity is produced with a steam turbine. The heat is used for heating buildings or as steam and heat for industrial processes. In Baden-Württemberg case the input consists of residues from firewood and wood waste.

Wood-based power production outside forest industry

There are also some wood-based energy plants producing only electricity in Baden-Württemberg.

Municipal solid waste incineration plant

Non-recyclable paper waste and wood-waste not suitable for wood-based energy plants are incinerated among other municipal solid waste.

3.5.3.1 Processes defined in M4/M5 – Bio-energy processes for 2005

M4

Process ID in the Client	Process name
1000171	Pellet mill

M5

1000652	Wood-based combined heat and power production (outside forest industry)
1000653	Wood-based power production (outside forestry sector)
1000656	Transport of ash to waste management
1000667	Transport of beech fire wood to small scale use
1000668	Small scale use for heating
1000679	Municipal solid waste incineration
1000737	Transport of spruce fire wood to small scale use
1000784	Home scale use for heating
1000785	Transport of pellets to home scale use
1000790	Transport of spruce fire wood to home scale use
1000791	Transport of beech fire wood to home scale use

3.5.3.2 Data acquisition and quality

As bio-energy is one of the fast evolving and rather young branches of the forestry wood chain, there were certain challenges to find applicable data. We used several different data sources like follow up routines from enterprises, data from experiments or scientific measurement and branch statistics. In addition we used expert opinions and in the reference future calculations and scenario calculations we used EFI-GTM results as a base to our future projections. Expert opinions were used in processes/indicators were no other data was available on the level it was needed for the Forestry Wood Chain. EFI-GTM results in reference future calculations and scenario calculations were used to get a consistent approach to calculations among partners. Most of the data in M5 2005 is of medium quality. In the reference futures most of the data is of medium or low quality, because of the demanding task of conducting future projections in the branch.

4 Reference futures A1 and B2

The modelling of chains and assigning of indicators was carried out on the base year 2005. Thereafter, two reference futures 2015 and 2025 were applied. Reference futures are dynamic ‘benchmark’ scenarios, but without major policy interventions (Deliverable D 1.4.7).

In 1996 the IPCC (Intergovernmental Panel on Climate Change) decided to develop a new set of emission situations that are described in the Special Report on Emission Scenarios (SRES). This set of scenarios is now known as the SRES scenarios, which were used by the IPCC for their third and fourth assessments. The scenarios are mostly developed for energy system parameters and related emissions. The underlying four reference futures, however, provide consistent storylines on the development of drivers like population growth and economic development in the future. Of the set of four SRES reference futures only the two contrasting A1 and B2 storylines were used within Eforwood. The two reference futures are described as follows:

“The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. In general public awareness concerning environmental issues is low (IPCC 2000).

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population, intermediate levels of economic development, and less rapid and more diverse technological change than in A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels (IPCC 2000)."

Both reference futures are quantified as 10-years and 20-years period development into the future. Starting in year 2005 as reference year, development of the FWC were determined for the years 2015 and 2025.

Consequently, next to the "Baseline 2005" the following reference future were applied:

- Reference future 2015 A1
- Reference future 2015 B2
- Reference future 2025 A1
- Reference future 2025 B2

As PD 1.4.7. describes, reference futures are "neither predictions nor forecasts, but are used to create a consistent image of a future. Each storyline assumes a distinctly different direction for future developments, and does not aim to be realistic. Conclusions should not be drawn from these storylines; nor are they an advocated view of EFORWOOD on the future of European forest and forest industry."

In order to describe the changes of the "world", a wide set of drivers was required to illustrate the divergent development of the futures by main driving forces. These drivers covered a wide range of key characteristics such as demographic change, economic development, and technological change. The drivers were of different importance in the various stages of the FWC or had a different influence on the same indicator in the individual processes along the FWCs. Table 18 shows the most important drivers applied in the different modules for the individual processes.

Table 18: Drivers applied in reference future A1 and B2

driver	development compared to 2005				Comment/Source	Module
	A1 2015	A1 2025	B2 2015	B2 2025		
Inflation rate	101.99%	101.99%	101.99%	101.99%	1+'[drivers_for_reference_futures_20081030.xls]IMAGE Deflation (GDP)'!B48	M2
Inflation rate	not used	not used	not used	not used		M3
Inflation rate	not used	not used	not used	not used		M4 fibre
Inflation rate						M4 solid wood
Inflation rate	not used	not used	not used	not used		M5 bio-energy
Inflation rate	103.00%	103.00%	102.00%	102.00%	Assumption based on Swedish development past 10 years	M5
Inflation rate	not used	nor used	not used	not used		M5
Productivity	not used	not used	not used	not used		M2
Productivity	128%	156%	123%	146%	Decided internally by M3	M3
Productivity	99%	95%	99%	95%	EFI-GTM data paper&board	M4 fibre
Productivity	105.0%	112.9%	105.3%	111.5%	EFI-GTM labour productivity, sawn wood (drivers_for_reference_futures)	M4 solid wood
Productivity	105.70%	112.3	105.70%	112.3	driver table, EU 27, ProdType: Market pulp	M5 bio-energy
Productivity	not used	not used	not used	not used		M5
Productivity	128%	156%	123%	146%	The same as M3 ("efficiency increase")	M5

driver	development compared to 2005				Comment/Source	Module
	A1 2015	A1 2025	B2 2015	B2 2025		
Timber prices	98.4%	103.4%	111.7%	126.6%	[drivers_for_reference_futures_20081030.xls]WoodPrices	M2
Timber prices	not used	not used	not used	not used	we used GDP	M3
Timber prices	98/104% con/non-con.	103/109%	112/107%	127/119%	EFI-GTM data Forest_products	M4 fibre
Timber prices						M4 solid wood
Timber prices	101%	105%	101%	105%	driver table fuel prices, OECD Europe, Sector 1, Industry, 5 Mod. Bio	M5 bio-energy
Timber prices	not used	not used	not used	not used		M5
Timber prices	not used	not used	not used	not used		M5
GDP	not used	not used	not used	not used		M2
GDP	132.87%	171.76%	121.87%	146.28%	driver table GDP- OECD Europe	M3
GDP	not used	not used	not used	not used		M4 fibre
GDP	132.67%	171.50%	122.05%	146.50%	EFI-GTM GDP development, OECD Europe	M4 solid wood
GDP	not used	not used	not used	not used		M5 bio-energy
GDP (OECD countries)	132.67%	171.50%	122.05%	146.50%	EFI-GTM GDP development, OECD Europe	M5
GDP (Eastern countries)	147.64%	221.84%	139.25%	186.64%	EFI-GTM GDP development, OECD Europe	M5
GDP	103.30%	103.30%	102.20%	102.20%	Assumption based on the M3 calc file	M5

driver	development compared to 2005				Comment/Source	Module
	A1 2015	A1 2025	B2 2015	B2 2025		
Labour cost	133%	172%	122%	146%	[drivers_for_reference_futures_20081030.xls]Quantified_drivers , wages increase	M2
Labour cost	132.87%	171.76%	121.87%	146.28%	driver list wage increase. For Indic. 2.1.3: 2005*wage increase*productivity	M3
Labour cost	111%	123%	111%	123%	driver table labour compensation, OECD Europe, average growth from 20 years	M4 fibre
Labour cost						M4 solid wood
Labour cost	111%	123%	111%	123%	driver table labour compensation, OECD Europe, average growth from 20 years	M5 bio-energy
Labour cost (OECD countries)	120.58%	145.05%	113.89%	129.29%	Trade volume (GDP adjusted) Index - 1,00=2005	M5
Labour cost (Eastern countries)	130.01%	176.76%	124.73%	154.58%	Trade volume (GDP adjusted) Index - 1,00=2006	M5
Labour cost	not used	not used	not used	not used		M5

5 Scenario of case study “Baden-Württemberg” - Bioenergy

Because driving forces can take different directions, it is important to develop multiple baseline scenarios. In Eforwood, four scenarios were attached to the reference futures (Deliverable D 1.4.7) as for example a technology change scenario which was implemented in the Scandinavian case study, a conservation scenario in the EU-FWC or a bio-energy scenario in the case study Baden-Württemberg.

For the calculation of indicator values for the reference futures a calculation scheme was developed. It includes general drivers from EFI-GTM as well as module specific drivers and assumptions and integrates the calculation formulas for the reference futures in the case studies and EU-FWC.

The Bio-energy scenario is modelled in one direction: as a high-impact scenario on top of a world within the framework of A1 reference future. Those reference futures are described in detail in “D1.4.7 Reference Futures and Scenarios for the European FWC” by Eric Arets et al. (2007). The bio-energy scenario is placed on top of the reference future and deals with the increased use of bio-energy from dendro-biomass with consequences for production. On the production side, biomass from the forest (e.g. harvest residues, stumps, industrial wood) and from the industry (sawdust, chips, bark, black liquor, rejects and downgraded assortments) are covered. The storyline of this scenario is described in full detail in PD 3.4.5: “Development and selection of M3-specific key scenarios for ToSIA at case study level”.

In the scenario under the A1 reference future the volume produced from the forest will not change, but a greater part of the harvested volume of small round wood is reallocated to bio-energy, and by this shift increase the competition for raw material with pulp and paper industries. Additionally harvest residues are utilised for bio-energy production and agricultural land is converted to short rotation plantations that will be used for dendro-bio-energy production.

6 Data acquisition, assumptions and data quality

The data were collected or derived from various sources, e.i. from European, national and federal statistics (Eurostat, FAO statistics), computer models (transport model, forest growth models, harvesting decision support models, EFISCEN, EFI-GTM) or partners’ own databases. In case where such information was not available, expert advice was gathered.

even though a generalised model approach was applied to describe production and manufacturing processes, not all process could be described for all sustainability indicators defined. In particular secondary small scale manufacturing processes of joinery and furniture production in the wood production sector lack a higher percentage of indicators due to the highly divers and specified production characteristics which could not be defined model-wise. A similar outcome can be found for M5 processes of consumption which also suffer from the high degree of aggregation.

As no official statistics existed for consumption of wooden goods and wood based products for Baden-Württemberg, the consumption of goods was estimated from German statistical data which was broken down per capita for Baden-Württemberg. Material import and export into and out of Baden-Württemberg was considered for roundwood, semi-finished products and end-products. Imports and exports from the other 16 federal states in Germany cannot be quantified; also European and overseas imports and exports can only be quantified on an overall German basis. To overcome this problem, volumes of material in exports and imports in each category were handled as net-balance. The volume of material was derived from known volumes produced in Baden-Württemberg and known volumes consumed. From that difference either an import or an export of wood volume in this category was assumed without differentiation wherefrom or whereto the material comes unless this is known by expert knowledge.

For the base year 2005, about 51% of the data collected originates from official statistics and publicly available databases, 27% on computer based models, and 21% on expert advice. However the classification of the representativeness of the data deviates slightly to the distribution above. 36% of indicator data are classified as high quality level, 21% as medium and 43% as low data quality (Table 19).

This reflects the partners' appraisal that also data from official statistics often did not directly meet the appropriate focus of information required for a certain indicator as defined in the DCP. Due to necessary assumptions and aggregations, any inaccuracies in the data for the base year can lead to far greater inaccuracies in the future scenarios. Any interpretation of results will require a strong insight into the definitions and assumptions applied in this case study.

Table 19: Representativeness of indicators

[number of indicators]	level of representativeness			
Module	high	medium	low	total
2	334	0	4	338
3	1217	703	521	2441
4	346	212	284	842
5	37	216	1494	1747
total	1934	1131	2303	5368

7 Management of the case study

The regional case study "Baden-Württemberg" was coordinated by Module 3. Partner 3 (ALU-FR) acted as the case study representative, Partner 27 (FVA) acted as the coordinator and ensured that the agreed terms of references were met. Modules 2, 4 and 5 were presented in the task force group by the nominated participants.

8 References

Bodelschwingh, E. v.: “Analyse der Rundholzlogistik in der Deutschen Forst- und Holzwirtschaft – Ansätze für ein übergreifendes Supply Chain Management”, Munich, 2005

Cremer, T.: expert opinion on bio-energy/transport distance of forest chips; Freiburg, 2007

Eltrop, Moerschner, Härdtlein, König (2006): Bilanz und Perspektiven der Holzenergienutzung in Baden-Württemberg. Report, Institut für Energiewirtschaft und Rationelle Energieanwendung, Stuttgart, Germany, 83 p. ISSN 0938-1228;

Hecker, M.: „Holztransport und Umweltschutz“, AFZ-Der Wald 4/2003; 2003

Ministerium für Ernährung und Ländlichen Raum Baden-Württemberg - Landesforstverwaltung (2007): http://www.wald-online-bw.de/pdf/jahresbilanz/jahresbilanz05.pdf and http://www.wald-online-bw.de/pdf/jahresbilanz/Bilanz_2004materialband.pdf (10.8.2007)

Müller, Sauter (2007): Die Forst- und Holzindustrie Baden-Württembergs 2005 eine sektorale, volkswirtschaftliche Bestandsaufnahme (in preparation)

Ochs, Duschl, Seintsch (2007): Struktur und Rohstoffbedarf der Holzwirtschaft. Teil 1 Studie „ Regionalisierte Struktur- und Marktanalyse der 1 Verarbeitungsstufe der Holzwirtschaft“ – Holzzentralblatt No 10, p. 269-271

Odenthal-Kahabka, J.: „Handbuch Sturm - Eine Arbeitshilfe für die Sturmschadensbewältigung“, http://www.waldwissen.net/themen/naturgefahren/krisenmanagement/fva_sturmhandbuch_DE ; Stand: 29.05.2007; 2005

Sauter, U.H.; Hehn, M.; Breinig, L.; Siemes, P. (2009): DVD „Holzernteverfahren“. Abteilung Waldnutzung der Forstlichen Versuchs- und Forschungsanstalt Baden-Württemberg, Freiburg. Version 1.0.

Smaltschinski, T.: expert opinion on transport distances per mode; Freiburg, 2007

Statistisches Landesamt Baden-Württemberg (2007): http://www.statistik.baden-wuerttemberg.de/Landwirtschaft/Landesdaten/LRt0714.asp (10.8.2007)

Statistisches Landesamt Baden-Württemberg (2007): http://www.statistik.baden-wuerttemberg.de/UmweltVerkehr/Landesdaten/Energiebilanz1992bis2004.pdf (10.8.2007)

Umweltministerium Baden-Württemberg (2006): Erneuerbare Energien in Baden-Württemberg 2005. 2nd ed., 27 p.

VDP (2007): Verband deutscher Papierfabriken e.V.; http://www.vdp-online.de/papierindustrie.html (personal communication)

VDS (2007): Verband der Deutschen Säge- und Holzindustrie e.V., Landesverband Baden-Württemberg (personal communication)

Wegener, G.: „Analyse der Transportketten von Holz, Holzwerkstoffen und Restholzsortimenten als Grundlage für produktbezogene Ökobilanzen“; 2004

Wolff, Folke (2005): Biomasse in Baden-Württemberg: ein Beitrag zur wirtschaftlichen Nutzung der Ressource Holz als Energieträger. PhD, University of Karlsruhe, Germany, 341 p.

Yue,Ch., Kohnle,U., Hein,S., 2008. Combining Tree- and Stand-Level Models: A New Approach to Growth Prediction. Forest Science 54, 553-566

ZMP (2006): Marktbilanz 2006 – Forst und Holz: ZMP Zentrale Markt- und Preisberichtsstelle GmbH, Bonn, 175 p.

Appendix

Conversion factors for M3

specific gravity of spruce 1 m^3 = 378,83 kg/m^3

specific gravity of beech 1 m^3 = 558,28 kg/m^3

share of C = 50% (0,5)

Acc. to the note by Jürgen Zell about the Information Flow over the M2/M3 boundary the reported conversion factors for M3 should be from m^3 (under bark) to tons of carbon **including** bark. Therefore:

Under bark volume = 90 % of the over bark volume

90 – 100

100 – x

x = 111 %

Conversion factor to:

tons of C = Volume under bark (m^3) * 1,11 (over bark) * 0,5 (C-share) / 1000 kg/t

Spruce

tons of C = Volume under bark (m3) * 378,83 kg/m^3 * 1,11 * 0,5 / 1000 = Volume under bark (m3) * 0,21025 t C/ m^3

Conversion factor to tons of C = 0,21025 t C/ m^3

Beech

tons of C = Volume under bark (m3) * 558,28 kg/m^3 * 1,11 * 0,5 / 1000 = Volume under bark (m3) * 0,3098454 t C / m^3

Conversion factor to tons of C = 0,3098454 t C / m^3