EFDM country report - Germany

Specific Contract 14

“Enhancement and testing of European Forestry Dynamics Model (EFDM) for even-aged forests”

In the context of the

“Framework contract for the provision of forest data and services in support to the European Forest Data Centre”
Reference Nr.: 388432

Project	Specific Contract 14 implementing Framework Contract No. 388432
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Authors	Susann Klatt, Joachim Rock, Heino Polley
Organization	Thünen Institute of Forest Ecosystems

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1 Introduction

In the specific contract 14 as part of the e-Forest Framework contract, it was our task to test the European Forestry Dynamics Model (EFDM) for even-aged forests in Germany. During this case study the results of the EFDM software were compared with the output of a German model.

2 Model setup and data structure

2.1 Data from the German National Forest Inventory

The data used in this study originates from the German National Forest Inventory (NFI called "Bundeswaldinventur" = BWI) using a standardized sampling procedure. The BWI is a large-scale, systematic cluster sample that is collected periodically, surveying the state of forests, and of forest production potential. It is a basically terrestrial sampling inventory that uses permanently marked sample points in a 4 km x 4 km grid whose resolution, at the request of the Federal States, has been increased on a regional basis.

The first National Forest Inventory (BWI 1987) covered only the territory of the Federal Republic of Germany ("Western Germany"), in its pre-1990 borders, and West Berlin. It was carried out in the period 1986 to 1989 (year of reference: 1987). The second National Forest Inventory (BWI 2002) was carried out in the period 2001 to 2003 (year of reference: 2002), as a repeat inventory in the "Western" German Federal States and as a first inventory in the "Eastern" (or, colloquially, "new") Federal States of the former German Democratic Republic, GDR (BMVEL 2001; BMELV 2005).

For 1987, no forest / non-forest information was available for the year 1987 at the relevant BWI points in the former GDR. In the interest of obtaining a maximally consistent database for the "new" German Federal States, the sample points were retroactively assigned to the land-use category *Forest Land* for those cases in which the BWI 2002, at the pertinent forest cluster points, listed trees that were more than 15 years old.

Data measured include tree species, age, diameter at breast height (DBH) of every tree at the sample plot (4 plots per grid point) as also height and upper diameter (in 7 m or 30% of the tree height) of 2 – 3 trees per plot. In addition, cause of death, dead wood volume, and various ecological parameters are noted in this inventory (for details please see BMELV (2001)).

Result tables for forest areas are broken down by superordinate parameters (e.g. Federal State, type of ownership). The area survey units of the German NFI can be further divided into subunits. Then, mixed stands are subdivided into pure stands of equal age and tree species. These are the ideational forest areas used in this study.

2.2 Definition of output variables according to German NFI data

2.2.1 Growing stock volume

The stock of sample trees of 7 cm or more DBH is determined from the sample trees having at least a DBH of 7.0 cm. These trees are selected using angle-count sampling with a basal area factor of 4. DBH of all trees reaching this threshold is measured, and height and upper diameter (in 7m total height or 30% of the tree height) of appr. 30% of these trees are also measured. Height and upper diameters of the other trees are modelled. DBH, the upper diameter (at 7 m height or 30% of the tree height) and the total tree height are used in trunk curve equations (spline functions) to estimate the volume of every single tree (see Kublin et al. 1988 and Kublin 2002 for details). This is done using the program BDAT (Kublin 2002). BDAT estimates both the stock volume over bark in m^3 (volR) and the harvestable volume under bark in m^3 (volE).

2.2.2 Biomass

In Greenhouse Gas Reporting, Germany currently applies a single tree approach to estimate the above ground biomass. DBH, tree height, D03 and the tree species group are the input variables / parameters for the regression model/equation used to estimate the above ground biomass of individual sample trees.

Trees with a DBH > 0 and < 7 cm are assigned DBH classes, and the mean of the respective DBH class is used to calculate volume and mass, instead of the measured DBH.

For regeneration (trees without DBH, i.e. trees with a height < 1,3 m) the height class (20 – 50 cm, 50 – 130 cm) is recorded in the inventory. The mean of the height class and the information broadleaved or coniferous tree is used as input variables in a regression model for these trees.

The models used to estimate above ground biomass are based on data of sample trees that were cut directly above the ground level, so the stump has a height of zero cm. They estimate single tree above ground biomass in total, without differentiation between different above ground components, like stem, dead or living branches etc.

For this study, we used species-dependent (expansion and) conversion factors to estimate total aboveground woody biomass from merchantable timber stocks. These factors have been derived from the Inventory Study 2008 (Oehmichen, Demant et al. 2011) and we assumed identical relations for standing stocks, growth and drain. For beech, the factor is 0.555 t / m3, for spruce it is 0.398.

2.2.3 Growing stock increment

Increment was calculated from repeated measurements of the BWI. Since the BWI 2002 could only repeat inventories in "Western" Germany, data derived from inventory plots in the "old" Federal States were applied to the whole of Germany.

2.2.4 Felling drain

The BWI estimates the drain from forests in two sets of data: first, if a tree had been inventoried and is missing in the consecutive inventory, its absence is recorded and his total volume accounted as "loss". Depending on parameters given in detail in Schmitz et al. 2008, part of the loss is considered usable timber and this part of the loss is attributed to harvest.

The drain estimated in WEHAM is not differentiated in pulpwood and saw timber, since this distinction is often based on market situation and / or wood quality, which is not assessed in the BWI and cannot be projected in WEHAM. The broad overlap between markets, meaning large volumes of saw-logs actually being used in pulp industries, and of pulpwood used in sawmills, makes the distinction obsolete in any case (at least for Germany).

2.3 State space classification definitions

The EFDM state space is established using 5 different factors: volume (10), age (18), tree species (2), ownership (4) and NUTS 1 regions (13).

2.3.1 Volume

We chose 10 volume classes for each of the two species. The limits of the volume classes were estimated using a general Chapman-Richards growth function on the volumes per hectare recorded for the ideational stands.

The *Chapman-Richards* function is commonly used to describe the cumulative growth curve:

$$Y = k * (1 - e^{(c*A)})^m$$

where Y is a dependent parameter of growth (volume)

k = upper asymptote/ potential maximum of response variable

c = growth rate at which response variable approaches potential max

A = age/ year (independent variable)

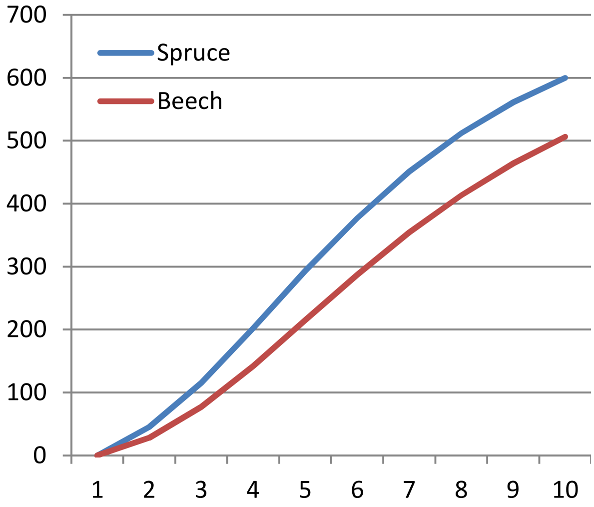
m = slope of growth

e = the base of natural logarithms

The growth function distributes the total volume over relative age, where relative age 100 as a maximum corresponds to the mean annual increment (MAI) culmination.

Table 1 Volume classes and volume class widths for spruce and beech

	Volume classes		Volume Class width	
	Spruce	Beech	Spruce	Beech
1	0	0	0	0
2	60	36	60	36
3	153	97	94	61
4	270	180	117	83
5	391	272	121	92
6	503	363	112	91
7	601	447	98	85
8	682	522	81	75
9	748	586	66	64
10	800	640	52	54



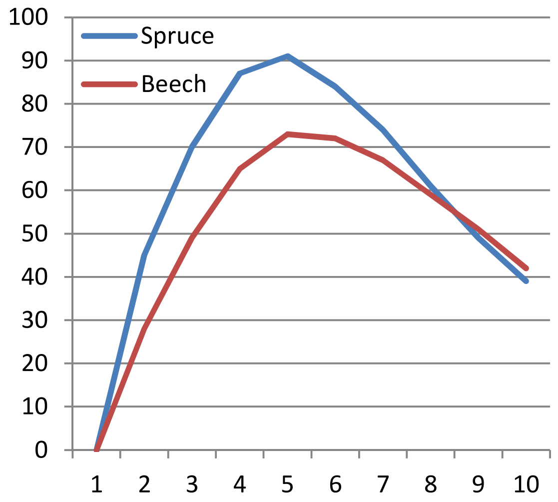


Figure 1 Volume classes of species estimated using the general Chapman-Richards growth function (left) and the corresponding volume class widths (right).

2.3.2 Age

The factor age is defined in 18 classes of 10 years due to the fact that the time between the NFI observations is 10 years. Therefore, no age transitions needs to be estimated. Only the first age class comprises 20 years (to facilitate comparisons with the NFI, where no finer distinction is done) and the last class reaches from 180 to the maximum age known in the NFI.

Table 2 Age classes

	Age in years
1	20
2	21 - 30
3	31 - 40
4	41 - 50
5	51 - 60
6	61 - 70
7	71 - 80
8	81 - 90
9	91 - 100
10	101 - 110
11	111 - 120
12	121 - 130
13	131 - 140
14	141 - 150
15	151 - 160
16	161 - 170
17	171 - 180
18	> 180

2.3.3 Tree species

The factor species is limited to European Beech (*Fagus sylvatica* (L.)) and Norway spruce (*Picea abies* (L.) Karst), being the main representatives of deciduous and coniferous tree species in Germany, respectively.

2.3.4 Ownership

The factor ownership is based on the four main types of ownership currently present in Germany:

- "national" – forest belonging to the Federal Republic (mostly former and actual military training grounds),
- "state" – forest belonging to the federal states and managed by the states' forest services,
- "communal" – forest belonging to municipalities, cities, churches, or other institutions, and
- "private" – forests belonging to individuals.

2.3.5 NUTS Regions

The factor NUTS originates from the 16 NUTS1 regions of Germany. The cities of Bremen and Hamburg are too small to be analyzed separately, and most of the forest belonging to the city of Berlin is located in the Federal State of Brandenburg, so Bremen and Hamburg were grouped together with Lower Saxony and Berlin was grouped with Brandenburg.

Table 3 The 13 grouped NUTS1 regions of Germany

	Land	Code
1	Baden-Württemberg	DE1
2	Bayern	DE2
3	Brandenburg + Berlin	DE3_4
4	Hessen	DE7
5	Mecklenburg-Vorpommern	DE8
6	Niedersachsen + Hamburg + Bremen	DE9_5_6
7	Nordrhein-Westfalen	DEA
8	Rheinland-Pfalz	DEB
9	Saarland	DEC
10	Sachsen	DED
11	Sachsen-Anhalt	DEE
12	Schleswig-Holstein	DEF
13	Thüringen	DEG

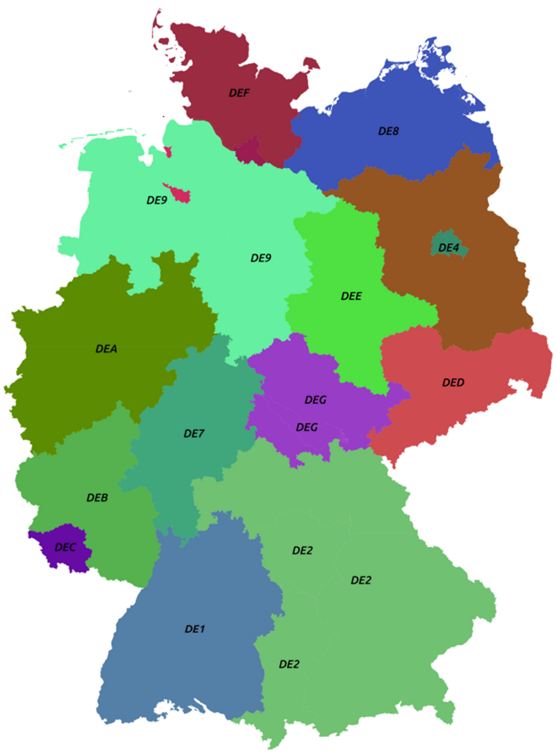


Figure 2 NUTS1 regions with original codes

2.4 Probabilities

For the estimation of no-management transition probabilities in Germany, we used “pair data” derived from NFI data. The estimation was carried out with the help of the function included in the EFDM package.

In Germany, management of forests might differ in between the Federal States as well as among different owners which could not be considered during this work. A standard forest management practice was assumed for defining the activity probabilities. In EFDM the thinning was done every 10 years and modelled as one volume class drop for all volume classes except the first.

2.5 Model used for comparison: WEHAM

The National forest growth model called WEHAM (“WaldEntwicklungs- und HolzAufkommensmodellierung“: Forest development and timber resource modelling) was developed at the Forest Research Branch of the Forest Service of the Federal State Baden-Wuerttemberg in close cooperation with the Thünen-Institute.

The term WEHAM is commonly used as name for a set of computer programs consisting of:

1. the WEHAM model itself (tree growth simulator),
2. the volume-calculator BDAT and
3. the accompanying database-related model control- and data aggregation software.

WEHAM has been specifically designed to meet the requirements of and work with the data provided by the German NFI. The model projects the growth of single trees measured at inventory plots, removal of trees by management activities, and the grading of the raw timber felled.

The model itself consists of three modules:

- a growth simulator,
- a management simulator and
- a grading model.

The **growth simulator** extrapolates tree dimensions (DBH, height) by using repeated measurements from trees included in at least two inventories. These are used to generate growth curves describing the development of DBH over age. Each tree sampled in a plot is referenced to a growth curve representative of / correlated with his DBH and age. The diameter increment over the period of interest is then derived from this growth curve. A tree from a given plot is representative for a number of X trees per hectare (which are considered to form an imaginary even-aged pure-species stand, an ideational stand) with the same attributes and dimensions. Management activities are modelled in a way that, e.g., cutting of a number of Y trees per hectare (declared within the management simulator and handed over to the grading module) assorts Y trees per hectare to the "cut" cohort, and (X – Y) trees per hectare remain.

Only trees of the main stand are considered (trees that have been recorded using an angle count factor of 4). The undergrowth or secondary trees are only minor parts of the stand total and are ignored.

The **management simulator** contains rules and algorithms describing forest management activities. The simulator describes, for every plot, the timing and intensity of thinning and cutting activities by using tree species, federal state, thinning type, thinning intensity (recurrence interval and target stand basal area), rotation period length, and target DBH as parameters. Type of ownership is also taken into account in some federal states where differences in management between ownership types are known. As default the stand basal area is compared with target basal area values derived from management tables and research plots.

Caps were identified to avoid unrealistic high harvesting at a single plot ("ideational" stand).

Thinning is oriented towards stand basal area (also stand density is possible) and if a certain threshold is reached the stand will be cut back to the basal area recommended in the respective management guidelines. By default, all activities are conducted on a yearly basis, but the output of the projections is aggregated in five years steps. The state of the forest (plot, single tree) at the beginning and at the end of this period as also growth, tree species distribution, forest area of a given species, growing stock volume, the mean annual increment during this period, mean annual raw timber availability, and harvest during this period are given. Because the development of single trees is projected, results can be aggregated at various levels, from plot to stand, region and state level, by species or species groups, and by age classes (normally five, 10 or 20 years), and at any combination of these classifications.

The **grading module** assorts every stem cut by thinning or harvesting into size classes customary in the trade.

The combination of input data, management and grading settings, taken together, is considered to be one single scenario of forest development. Changes in e. g. management settings result in different scenarios. The "reference scenario" used in the comparison has been established in 2004, using the results of the BWI 2002 as data input, and containing the management settings considered by experts from the Federal States Forest Services to be most likely employed in future years.

A detailed description of WEHAM and the associated other software solutions can be found in Anonymous 2005, Bösch 2005, Hennig 2003, Hennig 2009, Kublin 2002, and Kublin and Scharnagl 1988. Information on the reference scenario, and its precision, are given in (Dunger, Bösch et al. 2005; Polley und Kroiher 2006; Dunger und Rock 2009).

The comparison was conducted with the state of the projection in 2012 and 2022. For 2012, additional comparisons could be made with the results of the third BWI, which has 2012 as the reference year.

3 Results

3.1 Growing Stock Volume and Biomass

Growing stock volume (m^3, m^3 per ha) and biomass (t, t per ha), for Germany. Output per NUTS 1 (federal states) is included in the annex.

Table 4 Growing stock volume and biomass for beech and spruce in Germany

	Beech			Spruce		
	2002	2012	2022	2002	2012	2022
Growing stock volume ($m^3 * 10^6$)						
EFDM	367.8	303.7	257.4	1174.6	1053.3	942.8
WEHAM	544.1	531.5	515.8	1194.8	1298.3	1345.2
EFDM (% of WEHAM)	67.6	57.1	49.9	98.3	81.1	70.1
NFI	573.1	635.3		1208.5	1206.2	
Growing stock volume (m^3 / ha)						
EFDM	235	194	164	398	357	319
WEHAM	352	343	333	405	440	456
Growing stock biomass (t DM)						
EFDM	204.1	168.6	142.9	467.5	419.2	375.2
WEHAM	302.0	295.0	286.3	475.5	516.7	535.4
NFI	318.1	352.6		481	480.1	
Growing stock biomass (t / ha)						
EFDM	130.425	107.67	91.02	158.404	142.086	126.962
WEHAM	195.36	190.365	184.815	161.19	175.12	181.488

3.2 Growing Stock Increment

Growing stock increment (m³ per year, m³ per year per ha), for Germany. Output per NUTS 1 (federal states) is included in the annex.

Table 5 Growing stock increment for beech and spruce in Germany

	Beech		Spruce	
	2002-2012	2012-2022	2002-2012	2012-2022
Increment (m3 * 10^6/ a)				
EFDM	3.4	3.7	16.7	15.9
WEHAM	15.1	14.6	44.4	44.3
EFDM (% of WEHAM)	22	25	38	36
Annual increment (m^3 / a * ha)				
EFDM	3.2	3.5	5.6	5.4
WEHAM	9.8	9.5	15.1	15.0
EFDM (% of WEHAM)	32.7	36.8	37.1	36.0
NFI	10.3		15.3	

3.3 Felling Drain

Felling Drain (m³ per year; total t per year), for Germany. Output per NUTS 1 (federal states) is included in the annex.

Table 6 Felling drain and biomass for beech and spruce in Germany

	Beech			Spruce		
	2002	2002-2012	2012-2022	2002	2002-2012	2012-2022
Felling drain (m³ * 10^6 solid wood over bark / a)						
EFDM	9.8	8.3	8	28.8	27	26.4
WEHAM		16.3	16.2		33.6	39.6
EFDM (% of WEHAM)		51	49		80	67
NFI		13			51.2	
Felling drain (t / a)						
EFDM	5.4	4.6	4.4	11.4	10.7	10.5
WEHAM		9	9		13.4	15.7
EFDM (% of WEHAM)		51	49		80	67
NFI		7.2			20.4	

4 Discussion

4.1 Model performance

We tried to organize age and volume classes in way that they were most suitable to represent the structure of German beech and spruce forests. We were quite optimistic that the structure of ideational stands as they are derived from the German NFI would be represented by the matrix approach employed by EFDM. The results show that, in its current state, the EFDM grossly underestimates standing stocks, increment and drain for both species tested.

4.2 Model set up and parameterization

All in all, it took quite some time to prepare the data in a way to fit EFDM.

We tried to assess the number of age and / or volume classes necessary prior to running the model. We assumed that a modelling time step equal to the interval between two consecutive NFIs would be optimal. However, forest area in a given age class – volume class – cell could develop in different ways, so that parts of it could be found in four or more cells after one modelling step. We did not find out whether this was reflected sufficiently in the modelling approach.

In Germany, management of forests differs to some extend between the Federal States as well as among different owners. This affects mostly spacing and treatment. Other growth-affecting factors, like soil and climatic conditions, are not considered in this study. Unfortunately, site condition is not yet available for all plots in the data of the German NFI. Furthermore, using more factors influencing growth and management will increase the matrices and might negatively influence the possibilities to interpret the results.

The obtained results show that, at least in the current form and with the chosen factor classes (volume) and probabilities, EFDM is not suitable to adequately model the development of German spruce and beech forests. The development of standing stocks is detrimental to that occurring in reality, which means, that the activity probabilities and harvest intensities assumed in the model, and based on inventory data, are not efficient in modelling the development of the forests. This may be due to several reasons:

- The number of volume classes is comparatively low.
- The number of age classes employed is also low.
- The growth included in the model is not derived from measurements on all plots, but either from the development of plots from the “nomanagement” class, or from yield tables. Both would underestimate growth under current German conditions.

One of the major differences between German forests and e.g. forest management in Sweden is that silvicultural treatments have a higher frequency in Germany than in Sweden. This has several consequences that may afflict model performance when compared to the test applications in Scandinavian forests:

1 – The number of plots with ‘no management’ is very low and restricted, in general, to areas under protection. We assumed that growth in these areas was representative for all plots in all Federal States and for all types of ownership, but most likely this led to an underestimation of growth.

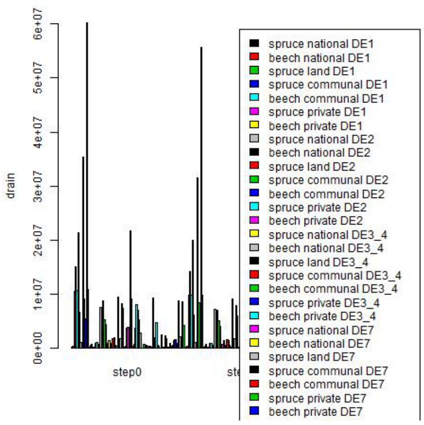
2 – The time step applied is, in most cases, longer than the mean recurrence interval of thinning, leading to an activity probability of 100%, and this further reduces the number of plots potentially included in the ‘no management’ group. In addition, we assumed one thinning per time step and a magnitude of this activity that lead to a drop of one volume class. In reality, stands – especially highly productive ones – may be thinned two times in ten years, and the volume removed may amount to more than the drop to the lower volume class. This would be reflected in WEHAM, but not in EFDM. It would thus be interesting to implement functionality for the estimation of activity probabilities in the model.

4.3 Model documentation and organization of output

The interpretation of the model output was hindered by the fact that there was no information included in the output files as to what units were used. Without documentation at hand, it was, for example, not possible to decide whether growth was given as “10^6 m^3 per year”, “m^3 per year and hectare” or “m^3 per hectare and time step”. As the value was quite off the mark all possibilities seemed equally likely.

Critique concerning model setup, documentation etc.:

- It was not clear whether “Step0” referred to a starting condition, the first period or else.
- The produced figures of the output were created partly dynamically, but not flexible enough and with questionable quality concerning the legend



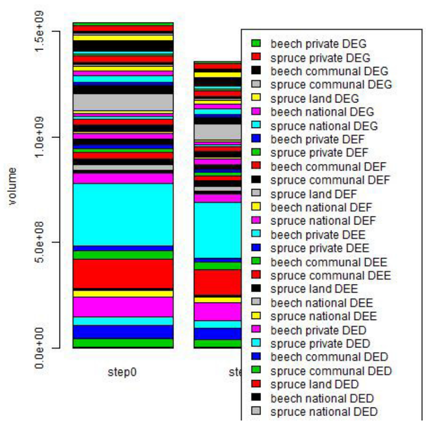


Figure 3 The barplots of drain by species, owner and nuts (left) and of total of volume by species, owner and nuts are not usable

5 Outlook

In Future work, the Chapman-Richards function should be optimized following D. Fekedulegn, M. Mac Siurtain, and J. Colbert, "Parameter estimation of nonlinear growth models in forestry," Silva Fennica, vol. 33, no. 4, pp. 327-336, 1999. Additionally, it could be modified, by making it a function of site, to generate a series of growth curves. Also, the performance of the model when increment was estimated from growth curves parameterized from recurrent single-tree measurements, and not from data aggregated on plot level, should be tested.

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7 Appendix

7.1 List of file annexes

	File name
Initial forest state	initstate.txt
No-management probabilities	nomgmtP.RData
Activity probabilities	actprobs.txt

7.2 Growing stock by NUTS1

Growing stock volume ($m^3 * 10^6$)

species	nuts	step0	step1	step2
beech	DE1	69.8	59.3	50.6
beech	DE2	71.6	60.8	51.6
beech	DE3_4	5.1	4.3	3.7
beech	DE7	48.5	38.5	33.1
beech	DE8	11.6	10.6	8.4
beech	DE9_5_6	33.7	26.9	22.6
beech	DEA	47.4	37.6	32.3
beech	DEB	38.5	32.4	27.4
beech	DEC	1.9	1.6	1.5
beech	DED	2.5	2.2	1.7
beech	DEE	5.5	4.6	4.0
beech	DEF	8.3	6.5	5.5
beech	DEG	23.5	18.5	14.8
spruce	DE1	201.8	181.0	163.1
spruce	DE2	485.5	429.7	385.7
spruce	DE3_4	4.4	4.1	4.1
spruce	DE7	75.4	67.9	62.7
spruce	DE8	12.4	12.0	11.1
spruce	DE9_5_6	63.4	57.0	50.3
spruce	DEA	109.6	100.9	88.8
spruce	DEB	66.2	60.5	55.4
spruce	DEC	5.3	5.2	4.4
spruce	DED	54.8	48.2	41.3
spruce	DEE	18.9	17.3	16.1
spruce	DEF	8.1	7.4	6.5
spruce	DEG	68.8	62.1	53.3

Growing stock volume (m^3 / ha)

species	nuts	step0	step1	step2
beech	DE1	256.7	218.0	186.2
beech	DE2	241.4	205.2	174.1
beech	DE3_4	170.0	144.0	125.7
beech	DE7	195.9	155.8	133.8
beech	DE8	197.0	180.8	142.5
beech	DE9_5_6	225.7	180.4	151.5
beech	DEA	312.7	248.1	212.9
beech	DEB	228.1	191.8	162.4
beech	DEC	115.8	94.3	92.6
beech	DED	152.4	133.6	107.2
beech	DEE	182.5	151.1	134.2
beech	DEF	282.3	221.7	187.6
beech	DEG	239.2	187.5	150.0
spruce	DE1	418.4	375.2	338.2
spruce	DE2	456.6	404.1	362.7
spruce	DE3_4	236.8	223.5	219.4
spruce	DE7	368.0	331.3	305.9
spruce	DE8	337.2	327.7	303.5
spruce	DE9_5_6	316.8	284.9	251.5
spruce	DEA	364.8	335.9	295.6
spruce	DEB	367.2	335.5	307.2
spruce	DEC	380.3	369.5	312.5
spruce	DED	334.7	294.5	252.0
spruce	DEE	347.1	317.5	294.3
spruce	DEF	335.8	307.8	271.0
spruce	DEG	334.0	301.5	258.9

7.3 Growing stock biomass by NUTS1

Growing stock biomass (t DM)					Growing stock biomass (t / ha)				
species	nuts	step0	step1	step2	species	nuts	step0	step1	step2
beech	DE1	38.7	32.9	28.1	beech	DE1	142.4	121.0	103.3
beech	DE2	39.7	33.8	28.6	beech	DE2	134.0	113.9	96.6
beech	DE3_4	2.8	2.4	2.1	beech	DE3_4	94.4	79.9	69.8
beech	DE7	26.9	21.4	18.4	beech	DE7	108.7	86.5	74.3
beech	DE8	6.4	5.9	4.6	beech	DE8	109.3	100.4	79.1
beech	DE9_5_6	18.7	14.9	12.5	beech	DE9_5_6	125.3	100.1	84.1
beech	DEA	26.3	20.9	17.9	beech	DEA	173.5	137.7	118.1
beech	DEB	21.4	18.0	15.2	beech	DEB	126.6	106.4	90.2
beech	DEC	1.1	0.9	0.9	beech	DEC	64.3	52.3	51.4
beech	DED	1.4	1.2	1.0	beech	DED	84.6	74.1	59.5
beech	DEE	3.1	2.5	2.2	beech	DEE	101.3	83.9	74.5
beech	DEF	4.6	3.6	3.1	beech	DEF	156.7	123.0	104.1
beech	DEG	13.1	10.2	8.2	beech	DEG	132.7	104.1	83.2
spruce	DE1	80.3	72.0	64.9	spruce	DE1	166.5	149.3	134.6
spruce	DE2	193.2	171.0	153.5	spruce	DE2	181.7	160.8	144.4
spruce	DE3_4	1.7	1.6	1.6	spruce	DE3_4	94.3	89.0	87.3
spruce	DE7	30.0	27.0	24.9	spruce	DE7	146.5	131.9	121.8
spruce	DE8	4.9	4.8	4.4	spruce	DE8	134.2	130.4	120.8
spruce	DE9_5_6	25.2	22.7	20.0	spruce	DE9_5_6	126.1	113.4	100.1
spruce	DEA	43.6	40.2	35.3	spruce	DEA	145.2	133.7	117.6
spruce	DEB	26.4	24.1	22.1	spruce	DEB	146.1	133.5	122.3
spruce	DEC	2.1	2.1	1.7	spruce	DEC	151.4	147.0	124.4
spruce	DED	21.8	19.2	16.4	spruce	DED	133.2	117.2	100.3
spruce	DEE	7.5	6.9	6.4	spruce	DEE	138.2	126.3	117.1
spruce	DEF	3.2	3.0	2.6	spruce	DEF	133.7	122.5	107.9
spruce	DEG	27.4	24.7	21.2	spruce	DEG	132.9	120.0	103.0

7.4 Growing stock increment by NUTS1

Increment (m3 * 10^6/ a)

species	nuts	step0	step1
beech	DE1	0,7	0,7
beech	DE2	0,6	0,5
beech	DE3_4	0,1	0,1
beech	DE7	0,4	0,6
beech	DE8	0,2	0,0
beech	DE9_5_6	0,2	0,3
beech	DEA	0,3	0,5
beech	DEB	0,4	0,4
beech	DEC	0,0	0,1
beech	DED	0,0	0,0
beech	DEE	0,1	0,1
beech	DEF	0,0	0,1
beech	DEG	0,2	0,2
spruce	DE1	2,6	2,6
spruce	DE2	5,0	5,3
spruce	DE3_4	0,1	0,1
spruce	DE7	1,2	1,3
spruce	DE8	0,3	0,2
spruce	DE9_5_6	1,3	1,2
spruce	DEA	2,1	1,6
spruce	DEB	1,1	1,1
spruce	DEC	0,1	0,1
spruce	DED	0,9	0,8
spruce	DEE	0,4	0,4
spruce	DEF	0,2	0,1
spruce	DEG	1,3	1,0

Annual increment (m^3 / a * ha)

species	nuts	step0	step1
spruce	DE1	5,3	5,4
beech	DE1	3,4	3,6
spruce	DE2	4,6	4,9
beech	DE2	3,3	2,8
spruce	DE3_4	7,3	7,9
beech	DE3_4	5,3	4,7
spruce	DE7	5,8	6,5
beech	DE7	2,7	4,1
spruce	DE8	8,6	6,6
beech	DE8	7,6	0,8
spruce	DE9_5_6	6,7	6,1
beech	DE9_5_6	2,7	3,7
spruce	DEA	6,8	5,3
beech	DEA	2,2	4,2
spruce	DEB	6,2	6,2
beech	DEB	3,7	3,7
spruce	DEC	8,8	3,9
beech	DEC	4,1	6,5
spruce	DED	5,6	4,9
beech	DED	5,7	3,2
spruce	DEE	6,5	6,5
beech	DEE	4,3	4,7
spruce	DEF	7,1	5,8
beech	DEF	1,8	4,1
spruce	DEG	6,3	4,8
beech	DEG	2,8	2,6

7.5 Felling Drain by NUTS1

Felling Drain ($m^3 * 10^6$ / a)

species	nuts	step0	step1	step2
beech	DE1	1,8	1,6	1,5
beech	DE2	1,7	1,4	1,4
beech	DE3_4	0,2	0,1	0,1
beech	DE7	1,4	1,1	1,1
beech	DE8	0,3	0,3	0,2
beech	DE9_5_6	0,9	0,8	0,7
beech	DEA	1,2	1,1	1,0
beech	DEB	1,0	0,9	0,9
beech	DEC	0,1	0,1	0,1
beech	DED	0,1	0,1	0,1
beech	DEE	0,2	0,1	0,1
beech	DEF	0,2	0,2	0,2
beech	DEG	0,7	0,5	0,5
spruce	DE1	4,7	4,4	4,4
spruce	DE2	10,6	9,7	9,7
spruce	DE3_4	0,2	0,2	0,2
spruce	DE7	1,9	1,9	1,9
spruce	DE8	0,4	0,3	0,3
spruce	DE9_5_6	2,0	1,9	1,8
spruce	DEA	2,9	2,8	2,7
spruce	DEB	1,7	1,6	1,6
spruce	DEC	0,1	0,1	0,1
spruce	DED	1,6	1,5	1,4
spruce	DEE	0,5	0,5	0,5
spruce	DEF	0,2	0,2	0,2
spruce	DEG	2,0	1,9	1,8

Felling Drain (t / a)

species	nuts	step0	step1	step2
beech	DE1	1,0	0,9	0,8
beech	DE2	0,9	0,8	0,8
beech	DE3_4	0,1	0,1	0,1
beech	DE7	0,8	0,6	0,6
beech	DE8	0,2	0,1	0,1
beech	DE9_5_6	0,5	0,4	0,4
beech	DEA	0,7	0,6	0,6
beech	DEB	0,6	0,5	0,5
beech	DEC	0,0	0,0	0,0
beech	DED	0,0	0,0	0,0
beech	DEE	0,1	0,1	0,1
beech	DEF	0,1	0,1	0,1
beech	DEG	0,4	0,3	0,3
spruce	DE1	1,9	1,7	1,7
spruce	DE2	4,2	3,8	3,9
spruce	DE3_4	0,1	0,1	0,1
spruce	DE7	0,8	0,7	0,7
spruce	DE8	0,1	0,1	0,1
spruce	DE9_5_6	0,8	0,8	0,7
spruce	DEA	1,2	1,1	1,1
spruce	DEB	0,7	0,7	0,6
spruce	DEC	0,1	0,1	0,1
spruce	DED	0,6	0,6	0,6
spruce	DEE	0,2	0,2	0,2
spruce	DEF	0,1	0,1	0,1
spruce	DEG	0,8	0,7	0,7