Chapter 21
Germany

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21.1 The German National Forest Inventory

21.1.1 History and Objectives

Forest statistics and forest inventories have a long tradition in Germany originating in the nineteenth century (Tomppo et al. 2010). The first German National Forest Inventory (NFI) with a nationwide sample-based data survey based on mathematical and statistical methods was implemented in the old German Laender within the years 1986–1990 (NFI1987). The NFI measures large-scale forest condition and the forest production potential. After reunification the second NFI (NFI 2002) was conducted expanding the methods used in the first NFI to the new German Laender.

In the spring of 2011, the field assessment for the Third National Forest Inventory was started. This NFI is referred to as NFI 2012, with measurements completed in February 2013. NFI 2012 is the first consecutive inventory for the entire Federal Republic since German reunification. A prerequisite in the development of the survey procedure was not to increase the effort associated with data collection. In addition, the comparability with former surveys should be maintained. Therefore, planning the assessment process was modified and extended cautiously. Nevertheless, the most notable innovations and changes are:

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- the collection of forest habitats and their conservation status under the Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora)
- the reduction of the minimum diameter for the collection of dead wood from 20 to 10 cm
- the exact location of sample points determined by GPS
- the exclusion of the forest-road assessment from the survey.

Additionally, the Laender of Saxony-Anhalt and Thuringia have condensed their network compared to the Second National Forest Inventory. Thus, the sample size is expected to increase about 9 % and there are now nearly 60,000 sample plots in forests with more than 420,000 sample trees for the whole of Germany.

21.1.2 Sampling Methods and Periodicity

The legal foundation of the German NFI changed with the "Second Act to amend the Federal Forest Act", passed by the German Bundestag on 17.6.2010. Thus the amended § 41a of the Federal Forest Act changed the framework for the National Forest Inventory. While it previously stated that the inventory should be repeated "as needed", there is now a cycle defined by ten years. In addition, the carbon stock data could be collected when necessary in the years between.

The NFI uses a stratified systematic one-phase cluster sampling with regionally different sampling intensities (sampling strata). The reference grid of the random sample is designed to fulfil the precision requirements at a national level. In order to increase the informative value, some German Laender regionally applied a denser sampling grid, so that in the end the sampling intensity over 22 % of the area has been doubled and on another 32 % quadrupled (Fig. 21.1).

Each cluster consists of four plots arranged in a square with side lengths of 150 m. Along borders the cluster size could decrease. Only plots in the forest are sampled. The sample plots are marked using permanent concealed markers. In every plot within the forest, the data recorded varies depending on the survey units e.g. sample plot circles, angle count sampling (Fig. 21.2).

21.1.3 Data Collection

Two types of data were recorded. Firstly, the general point data like, cluster number, plot number, sampling strata, German Land, district, municipality, forest region, accessibility, forest/non forest, forest classification, ownership, slope, altitude, natural altitudinal zones, land use changes, etc.

Secondly, the tree data differentiated by: (a) data for structural and biotope attributes like naturalness of the tree species composition or to derive forest habitats

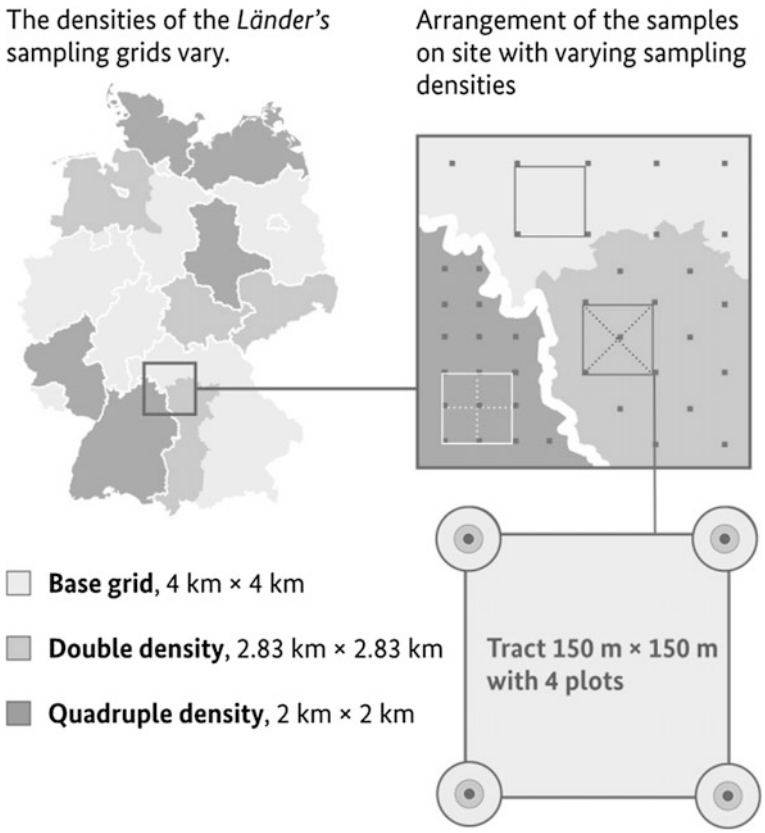

Fig. 21.1 NFI sampling grid (Federal Ministry of Food and Agriculture 2015)

and their conservation status and (b) data to estimate volume, volume change and so on.

To describe the stand, data from the angle count sampling with basal area factor 1 or 2 and from the 10 m radius circle were used. The 1 and 2 m circles were used to derive estimates of regeneration; abundance, stem number, species composition and biomass.

The typical forest parameters of volume, growth and drain were estimated based on the angle count sampling with a basal area factor 4. The following parameters were assessed: tree number, tree species, azimuth, horizontal distance, canopy class, diameter at breast height (dbh), social position according to Kraft, damage, special habitat tree attributes and pruning. The age of the trees is taken from the preliminary data of the cluster established before the actual survey. If the preliminary details of the cluster contain a false age or no age at all, the annual growth rings on stumps or the number of branch whorls are counted. Alternatively, the age is estimated on the basis of the local growth dynamics.

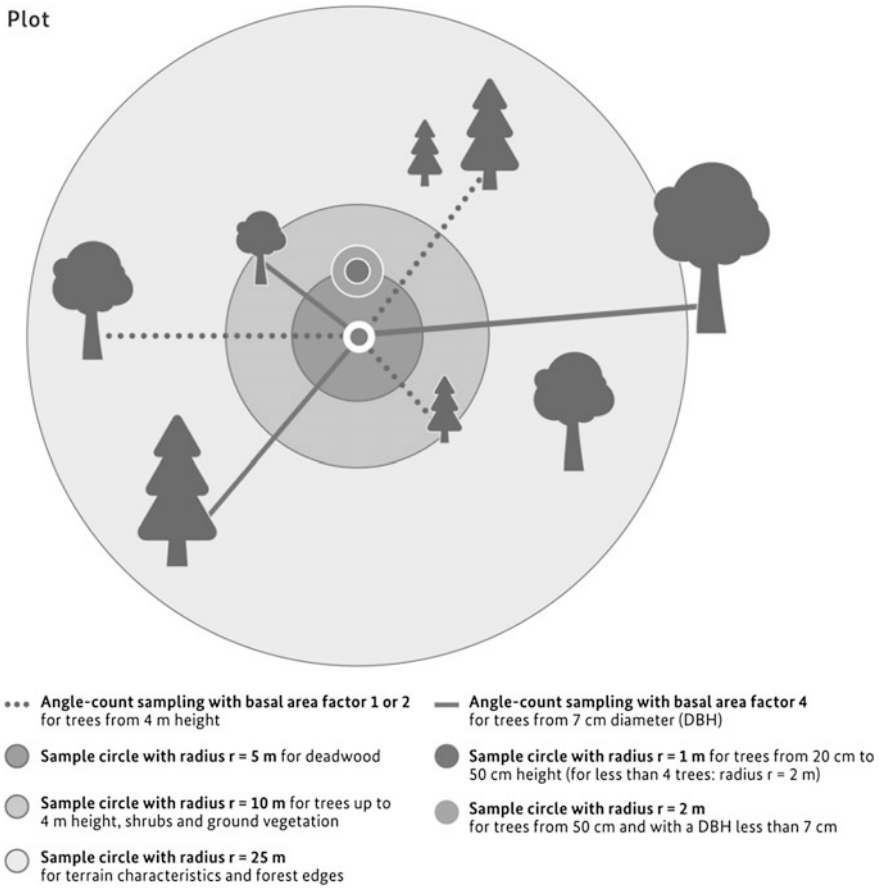

Fig. 21.2 Surveys at the sample point (Federal Ministry of Food and Agriculture 2015)

The dbh is measured on all trees included in the angle count sampling (ACS). On a sub-sample of approximately 1/3 of all ACS-trees the height and the diameter at 30 % of the total tree height (d_{03}) is measured. For the other trees both parameters are modelled depending on tree species groups.

The amount of dead wood for three different tree species groups, seven types of deadwood (lying, standing, root stock, etc.) and 4 degrees of decomposition was derived from circle with 5 m radius.

To avoid biases of the tree inclusion probability for those trees in the near of forest edges, border effects must be eliminated Therefore, all border lines of forest/non forest edges and of stand edges are measured within a maximum distance of 25 m radius by accessing two polar coordinates for each border lines.

A more detailed description can be found in the field guide (BMELV 2011).

21.1.4 Data Processing, Reporting and Use of Results

During and after the field assessments all data must pass two validation checks. Data with warnings must be checked again; and data with errors must be corrected. Validation checks are implemented at four stages. Checks within the field software on tree, plot and cluster level, defined check routines done by Land inventory administration and defined check routines done by the federal inventory administration.

Before the evaluation process can start, a lot of routines must be developed, fitted and programmed to derive attributes not assessed in the field. Three stages have to be distinguished: object level attributes for one time point, object level attributes for two time points and plot level attributes for one time point and their changes between two time points.

Object attributes (trees, dead wood pieces, forest borders) to derive for one time point are:

- represented number of stems per hectare including forest edge correction
- stand area of each tree
- modelled tree heights using unit height-diameter curves
- upper diameters at 30 % tree height (d_{03}) using single tree regression models f(tree species, dbh, height) according to Sloboda et al. (1993)
- volume as f(tree species, dbh, d_{03}, height)
- above ground biomass of living trees, f(tree species, dbh, d_{03}, height)
- below ground biomass of living trees, f(tree species, dbh)
- volume of dead wood pieces, f(tree species, length, lower and upper diameter)
- biomass of dead wood pieces, f(tree species, length, lower and upper diameter, degrees of decomposition)
- forest edge length, exposition of forest edge.

If new models were used, i.e. for biomass, the attribute must be derived again with the new model for the same tree attribute from the last occasions.

Object attributes derived from two time points are: growth of diameter, height, volume and biomass. The basic attributes dbh and height for new selected angle count sampling trees (in-growth, on-growth and non-growth trees) and for cut or mortality trees were modelled using a differential equation according to Sloboda (1971).

For plots the following attributes were derived: forest type, naturalness of the tree species composition, forest habitat and classifications for height zones, exposition, slope, etc.

For each plot the variable of interest (biomass, volume, etc.) per hectare is calculated as the sum of hectare values represented by individual trees. These estimates per hectare are aggregated to a mean per hectare forest and non-forest.

The total estimate is derived by multiplying the mean with the total area of Germany. Dividing the mean by a proportion or one total by another total respectively results in a ratio estimator, i.e. the growing stock per hectare forest. Means, totals and ratios can be estimated for nearly all possible combination of classification variables: Germany, Laender, tree species, age classes, forest classification, ownership, forest habitats, classes of naturalness, natural altitudinal zones, etc.

For change estimations data from two consecutive NFI assessments are used. All changes in forest area and wood resources are assessed on permanent plots. Every change in wood resources are related to the population of trees with a dbh ≥ 7 cm. Volume estimates below this threshold are provided for FAO reporting. For LULUCF and Kyoto reporting biomass estimates are also derived from the regeneration data. Changes in forest area and wood resources are estimated in the same way as described above for means, totals and ratios, but calculating the difference first.

Experience gained from the Second National Forest Inventory and the Inventory Study 2008 (Oehmichen et al. 2011), the collected data is of interest for many stakeholders on national and sub-national level. In particular, forestry and environment policy stakeholders, the forestry and timber industry as well as the forest science needs the data for the analysis of the current situation and the future management of our forests.

The international reporting requirements are the Forest Resources Assessment (FRA) of the Food and Agriculture Organization of the United Nations (FAO), the submissions on Land Use, Land-Use Change and Forestry (LULUCF) under the United Nations Framework Convention on Climate Change (UNFCCC) and under Article 3.3 and 3.4 of the Kyoto Protocol, the Decision 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol, the indicators and criteria for sustainable forest management for FOREST EUROPE (FOREST EUROPE, UNECE and FAO 2011), and on the conservation status of natural habitat types under the Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora).

At national and sub-national level the German NFI data are the scientific basis to estimate and to evaluate the current status of forests and their retrospective development. They are used to evaluate forest policy strategies like Forest Strategy 2020 or the silvicultural guidelines of the Laender. In some Laender the NFI data are the only source of information about conditions in private forest ownership. In addition, the NFI data are used for modelling the “future forest development and potential wood outcome” (WEHAM) under different management and policy scenarios for the next 40 years.

21.2 Land Use and Forest Resources

21.2.1 Classification of Land and Forests

21.2.1.1 General Land Classification

In the preparatory phase for each NFI assessment all sample plots were classified in two classes: "definitively non forest" and "possible forest". Therefore the administration of the inventory within each German Land uses available maps and aerial orthophotos. All plots classified as possible forests are visited in the field. The final decision to classify a plot as forest or non forest in the field, is based on the following forest definition:

Forest within the meaning of the NFI is any area of ground covered by forest vegetation, irrespective of the information in the cadastre or similar records. The term forest also refers to cut-over or thinned areas, forest tracks, fire-breaks, temporarily unstocked land and clearings, forest glades, feeding grounds for game, landings, forest aisles, further areas linked to and serving the forest including areas with recreation facilities, overgrown heaths and moorland, overgrown former pastures, alpine pastures and rough pastures, as well as areas of dwarf pines and green alders. Heaths, moorland, pastures, alpine pastures and rough pastures are considered to be overgrown if the natural forest cover has reached an average age of five years and if at least 50 % of the area is covered by forest.
Areas with forest cover in open pasture land or in built-up areas of under 1000 m^2, coppices under 10 m wide, Christmas tree and ornamental brushwood plantations, commercial forest-tree nurseries as well as parkland attached to country houses are not forest within the meaning of the NFI. Watercourses up to 5 m wide do not break the continuity of a forest area.

In 2012 the forest area amounted 11,419,124 ha. All other land uses covers 24,301,656 ha.

If sampling points changed their status from forest to non-forest or vice versa since the last NFI one of the following land use categories will be assessed as "land use category before" or "land use category after" conversion additionally:

Settlement areas:

- industrial, commercial and traffic areas, including vegetation-covered slopes along the traffic areas
- built-up, sealed off areas not assigned to any other category (e.g. housing estate)
- mining sites, landfills, dumps, open areas with no or little vegetation (areas that naturally have these surfaces are in their terminal stage and do not become forest. The existing rare cases are assigned to this category as they often originate from this use of land)
- urban green, other unsealed areas, sport and recreation areas.

Agricultural areas:

- arable land
- permanent crops (vines, fruit stands, hops, tree nurseries not belonging to the forest)
- permanent grassland (pastures, meadows, natural grassland, heaths, transitional stages between forest and shrubs).

Other areas:

- wetlands
- bodies of water.

Errors:

- plot was already clearly non-forest before (missing or wrong designation in NFI 2002)
- plot was already clearly forest before (missing or wrong designation in NFI 2002).

Therefore, the German NFI cannot provide area estimates for all land use classes and their change. Only area estimates of land use change classes to or from forest are possible (Table 21.1).

Table 21.1 Land use change from and to forest between NFI 2002 and NFI 2012

Type of land use after or before	Deforestation (1000 ha)	Afforestation (1000 ha)	Corresponding FRA classes (FAO 2004)
Industrial, commercial and traffic areas	16,337	6468	OL, OlwTc
Built-up, sealed off areas not assigned to any other category	4290	596	OL, OlwTc
Mining sites, landfills, dumps, open areas with no or little vegetation	16,506	27,470	OL, OlwTc
Urban green, other unsealed areas, sport and recreation areas	4188	700	OL, OlwTc
Sum of cultivated areas	41,322	35,236	
Arable land	2992	12,443	OL, OlwTc, intersection with forest
Permanent crops	2292	2296	OL, OlwTc, intersection with forest
Permanent grassland	9874	49,133	OL, OlwTc, intersection with forest
Sum of agricultural land	15,159	63,873	
Wetlands	1395	6271	OL, OlwTc
Bodies of water	399	2494	OL, OlwTc
All types of land use change	58,277	107,874	

For carbon reporting under the UNFCCC (LULUCF) and the Kyoto protocol regulations the land use information from the NFI plots are also used. Hence, the carbon reporting system is independent from the NFI. Herein, the NFI land use information is only one source from an overall of 5 sources used for carbon reporting. But it is important to know, that within the carbon reporting system the same sampling grid is applied to assess LULUCF (Freibauer et al. 2014).

21.2.1.2 General Classification of Forest

The forest classification distinguishes between:

- forest, temporarily unstocked land
- forest, unstocked forest land
- forest, stocked timber-land.

Temporarily unstocked areas are areas of timber-land that are temporarily without forest cover. In 2012 the area of this category amounts 0.4 % of the whole forest area. Unstocked forest land includes forest tracks, forest aisles over 5 m wide, landings, non-commercial forest-tree nurseries belonging to the forest, seed and plant nurseries, food plots and meadows, yard and building areas used for forestry purposes, recreational facilities linked to the forest as well as rocks, boulders, gravel and water located in the forest. Swamps and moors located in the forest are also considered unstocked forest land provided that they are not overgrown. The unstocked forest land covers 3.2 % of the total forest area (Table 21.2).

21.2.1.3 Forest Classifications by Ownership Categories

The official forest statistics include the following ownership categories (Table 21.3):

- state forest (national property)
- state forest (Land property)
- communal forest:
  - municipal forest
  - church forest assigned to communal forest
  - community forest assigned to communal forest
  - cooperative forest assigned to communal forest

Table 21.2 Classification of forests and their area including not accessible forest (NFI 2012)

Classification of forest	Area (1000 ha)	Area (%)
Stocked timber-land	11,012	96.4
Temporarily unstocked land	41	0.4
Unstocked forest land	365	3.2
Forest	11,419	100

Table 21.3 Forest area including not accessible forest according to the national forest definition by ownership categories (NFI 2012)

Ownership category	Area (1000 ha)	Area (%)
State forest (national property)	404	3.6
State forest (land property)	3310	29.0
Communal forest	2220	19.4
Private forest + Treuhand forest	5486	48.0
Forest	11,419	100

  - communal forest under exclusive ownership or under exclusive sponsorship of the Land government
  - communal forest under ownership or under exclusive sponsorship of the national government.
- private forest:
  - private forest (in the narrower sense)
  - church forest assigned to private forest
  - community forest assigned to private forest
  - cooperative forest assigned to private forest
  - private forest under exclusive ownership or under exclusive sponsorship of the Land government
  - Private forest under exclusive ownership or under exclusive sponsorship of the national government
- forest under Treuhandanstalt administration (Treuhand forest).

The use of the subclasses (for instance municipal forests) is optional. This is determined uniformly for each German Land.

In Germany the distribution of forest land ownership is very heterogeneous and forced by historical developments. For example in North Rhine-Westphalia the private forest has a proportion of 67 %, in the neighbouring Rhineland-Palatinate it is only 26 %. Those lands with a high rate of forests in state ownership include Mecklenburg-Western Pomerania and Saarland with more than 40 %. The lowest rate of state forests is counted in North Rhine-Westphalia. The highest rate of communal forest was assessed in Baden-Württemberg, the lowest proportion was estimated in Brandenburg.

21.2.1.4 Classification by Legal and Other Restrictions for Wood Use

Restrictions on use exist if the potential timber use cannot be realised. This includes restrictions on the use of timber both due to legal regulations or other external reasons and internal reasons like fragmented ownership, terrain features etc. Restrictions on use are classified into four classes (Table 21.4):

Table 21.4 Accessible forest area according to the national forest definition by ownership categories (NFI 2012)

Restriction of use	Area (1000 ha)	Area (%)
1/3 of usual harvest is to be expected	204	1.9
2/3 of usual harvest is to be expected	285	2.6
Forest utilisation not allowed or not to be expected	450	4.1
No restrictions of forest utilisation	9948	91.4
With or without usage restriction	10,888	100

- no restriction on the use of timber
- use of timber not authorised or not to be expected
- approx. 1/3 of the usual harvest to be expected
- approx. 2/3 of the usual harvest to be expected.

On more than 500,000 ha external reasons are responsible for the reduced expectation of wood use. Forests amounting to 360,000 ha are protected for nature conservation. Approximately 76,000 ha have restrictions in utilisation due to protective reasons (i.e. water recreation) and 22,000 ha are protected for recreational reasons. The remaining 45,000 ha have other restrictions which are not explicitly described.

Internal reasons for restrictions in utilisation of wood was assessed on 611,000 ha with more than one third due to terrain features and nearly one fifth by own initiative of the owners. Overall, 8.6 % of the whole forest area had restrictions on wood use. Forest utilisation is not allowed or is not to be expected on 4.1 % of the total forest area.

21.2.1.5 Other Classifications

Many other classification attributes are incorporated into the NFI, such as: accessibility, management type and timber harvesting conditions. All classifications that group the whole plot into one of the classes are referred to as real classifications. A very detailed database of NFI results is available in BMEL (2014).

In addition, the forest area by tree species-groups and age classes are not derived by plot or proportions of plots but are calculated using the area per single tree. Therefore, tree species group dependent regression functions are used. Afterwards each single tree area will be modified proportionally in a way that the sum of area of all trees which belongs to the main stand or plenter forest/selection forest (high forest in which trees of different ages and different dimensions are mixed in small aggregations and over a long period of time) meets 10,000 m^2 or 1 ha respectively. All these classifications based on such modified areas per tree are called calculated pure stand classifications (Table 21.5).

The NFI 2012 results show that more than 76 % of forests are mixed forests. More than 2.2 million ha are stocked with mixed coniferous and deciduous tree

Table 21.5 Accessible forest area according to the national definition by species and species groups (NFI 2012)

Species and species groups	Area (1000 ha)	Area (%)
Oak spp. (*Quercus* spp.)	1130	10.4
Beech (*Fagus sylvatica*)	1680	15.4
Other deciduous trees with long life expectancy	770	7.1
Other deciduous trees with short life expectancy	1148	10.5
Spruce (*Picea spp incl. all other coniferous tree species*)	2763	25.4
Fir (*Abies* spp.)	183	1.7
Douglas fir (*Pseudotsuga menziesii*)	218	2.0
Pine (*Pinus* spp.)	2430	22.3
Larch *(Larix* spp.)	307	2.8
Temporarily unstocked area	40	0.4
Total forest (calculated pure stand)	10,888	100.0

Table 21.6 Accessible forest area according to the national definition by age-classes (NFI 2012)

Age class (years)	Area (1000 ha)	Area (%)
1–20	1067	9.8
21–40	1631	15.0
41–60	2228	20.5
61–80	1711	15.7
81–100	1389	12.8
101–120	1089	10.0
121–140	693	6.4
141–160	469	4.3
>160	350	3.2
Missing	260	2.4
Total forest (calculated pure stand)	10,888	100.0

species. More than one third of the trees are between 41 and 80 years (Table 21.6). One reason for this unbalanced age class distributions is due to the replanting after the Second World War. Overall, German forests are becoming older. The area of age classes greater than 100 years grew by 0.8 % per class at minimum since 2002. Also the area of trees older than 160 years was increasing in the last decade by 1 %. Contrastingly the area of the both youngest age classes decrease by more than 2 % each.

21.2.2 Wood Resources and Their Use

21.2.2.1 Standing Stock, Increment and Drain

All results of standing stock, increment and drain are estimated from the selected trees within the angle count sampling with basal area factor 4 from one time point (standing stock) or from two consecutive assessments (increment and drain). The volume of standing stock, increment, and drain are presented in Table 21.7. The increment and drain data are average annual values for the period 2002–2012.

Standing timber stock includes every living tree and every tree that probably died less than 12 months ago with a dbh of 7 cm or more and consists of all aboveground parts of the stem including the stump, the bole with bark and all parts of branches greater than 7.0 cm according to the German NFI definition. For trees with a dbh < 7 cm no volume is estimated.

In addition, the standing harvestable volume under bark is calculated and does not include stump, bark, rotten parts and dead or sawn branches. Overall, the standing harvestable volume under bark amounts round about 76.5 % of the standing timber stock. The relationship of standing timber stock and standing harvestable volume under bark depends on the following parameters: tree species group, dbh, d_{03} and tree height.

The annual increment per hectare is estimated to be 11.23 m^3 for the stocked timber-land. Taking into account only the trees of the main stand or plenter forests, the calculated pure stand annual increment per hectare is 10.85 m^3. The highest calculated annual pure stand increment per hectare is assessed for spruce area, fir

Table 21.7 The volume of standing stock, increment, and drain on accessible forest land (NFI 2012)

Tree species and species group	Standing stock (m^3/ha)	Standing stock (1000 m^3)	Increment (1000 m^3/year)	Drain (1000 m^3/year)
Oak	33	361,231	9353	5144
Beech	58	635,258	18,293	13,958
Other deciduous trees with long life expectancy	19	204,369	6596	3061
Other deciduous trees with short life expectancy	20	219,712	7283	5497
All deciduous trees	130	1,420,570	41,526	27,660
Spruce	111	1,206,199	45,671	52,505
Fir	9	93,434	2997	2116
Douglas fir	7	72,731	3864	1646
Pine	71	767,814	24,180	20,006
Larch	9	102,224	3365	2408
All coniferous trees	206	2,242,402	80,076	78,681
All tree species	336	3,662,972	121,602	106,341

area and Douglas fir area with 15.3, 16.3 and 18.9 m^3, respectively. The smallest annual increment is estimated with 6.4 m^3 per hectar for the area of other deciduous trees with short life expectancy, i.e. birch, *Salix* spp. and so on.

21.2.2.2 Tree Species and Their Commercial Use

The German official harvested wood statistics, the so called "Holzeinschlagsstatistik" provides estimates for four wood species groups (Seintsch 2010):

- spruce, fir, douglas fir and other coniferous wood
- pine and larch
- oak
- beech and other deciduous woodland

In 2012, approximately 50 % of the harvested wood comes from tree species group spruce (www.destatis.de). The logging rate has increased in the years 2002 to 2006 up to 55 % (Seintsch 2010), mainly in smaller diameter and age classes. Round wood accounted for 68, 16 % as industrial wood, and 12 % as energy wood. Nearly 25 % of harvested wood belongs to the species-group pine, which was used mainly as round wood (47 %) and industrial wood (37 %). The species-groups beech (23 % of total wood supply) and oak (4 % of total wood supply) had the highest proportion of use for energy purposes with 36 and 34 % respectively followed by industrial wood and round wood.

21.3 Assessment of Wood Resources

21.3.1 Forests Available for Wood Supply

Within the German NFI the non-availability will be assessed as opposed to the availability of wood for supply. The non-availability for wood supply is defined by restrictions caused by external or internal reasons. Restrictions caused by internal reasons include those ones due to the use of timber both due to legal regulations. Restrictions on use exist if the possible uses of timber cannot be realised. The reason for such restrictions is indicated as external, internal or both reasons.

External reasons for the restriction on use

- no external restrictions on use
- nature conservation
- protection forest
- recreational forest
- other external reasons.

Where there are several external reasons, the most important reason is selected.

Internal reasons for the restrictions on use

- no internal restrictions on use
- fragmented ownership of uneconomic size (e.g. if the system of land tenure provided for the equal division of land among all qualified heirs)
- stand-alone location
- insufficient accessibility
- site characteristics, wet location
- little expected yield (mean total increment <1 m^3/ha/yr)
- areas protected at owner's discretion (e.g. natural forest reserves)
- other internal reasons

In case of several internal reasons, the most important one is indicated.

21.3.2 Wood Quality

Within the German NFI no assessment of stem quality or timber assortments is conducted.

21.3.3 Assessment of Change

Change estimations are calculated using NFI data assessed consecutively on permanent plots.

Survivor trees
The increment of survivor trees is the difference of the modelled volume between t_2 and t_1. This increment divided by the plot-wise count of years between two consecutive assessments results in the increment per year. The representation factor per hectare is taken from the end of the inventory period.

New trees in ACS (ingrowth, ongrowth and nongrowth trees) on forest remaining forest
For the new trees in the ACS sample only the volume at the end of the period is known. The volume at the beginning of the period is modelled using the same volume model. Therefore the dbh, height and d_{03} at the beginning of the period are modelled by growth functions. Afterwards the difference of both values is calculated as increment; divided by the plot-wise count of years between two consecutive assessments results in the increment per year. The representation factor per hectare is taken from the end of the inventory period.

Increment of drained trees from the ACS on forest remaining forest
For trees, which could be assessed only at the beginning of the period, the dbh, height and d_{03} will be modelled by growth functions up to the mid-point of the period. Then the difference is calculated as increment. The number of trees per hectare from the beginning of the period acts as representation factor per hectare.

New trees in ACS on other land converted to forest land
All new forest plots are assumed to grow into the population in the middle of the period. Thus, the parameters required to estimate the volume for each single tree are modelled back to the half of the inventory period. For trees, which are younger as the half of the inventory period the volume is 0. The representation factor per hectare is taken from the end of the inventory period.

Increment of trees from the ACS on forest converted to other land
For all forest plots that are converted to other land uses the conversion date is set by definition to the middle of the inventory period. All tree parameters are estimated using the same method as was used for drain on those plots that remained as forest.

Drain
The volume of drain is defined as the sum of the volume from the beginning of the inventory period plus the increment up to the half of the inventory period for those trees removed from the ACS on forest remaining forest and forest converted to other land use. To calculate the per hectare representation the basal area factor from the beginning of the period is used.

21.3.4 Other Wooded Land and Trees Outside Forests

Within the German NFI no assessment of "Other wooded land" and "Trees outside forest" is conducted.

References

Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (2011) Aufnahmeanweisung für die dritte Bundeswaldinventur (2011–2012), 2. geänderte Auflage, Mai 2011 (BMELV (2011): Survey instructions for the 3rd National Forest Inventory (2011–2012), 2nd revised version, May 2011)

Bundesministerium für Ernährung und Landwirtschaft (2014) Der Wald in Deutschland – Ausgewählte Ergebnisse der dritten Bundeswaldinventur (BMEL (2014): The forests in Germany—selected results of the third national forest inventory), www.bwi.info. Accessed 10 Apr 2016

Federal Ministry of Food and Agriculture (2015) The Forests in Germany. Selected results of the third national forest inventory

FOREST EUROPE, UNECE and FAO (2011) Sustainability of European forests: status and trends in sustainable forest management in Europe. Ministerial Conference on the Protection of Forests in Europe, FOREST EUROPE Liaison Unit Oslo. 344 p

Freibauer A, Dunger K, Gensior A, Riedel T, Laggner A, Laggner B, Stümer W (2014) Land use, land use changes and forestry (CRF sector 5): chapter 7.1 overview. In submission under the United Nations framework convention on climate change and the Kyoto protocol 2014. National inventory report for the German greenhouse gas inventory 1990–2012. Federal Environ Agency 2014:484–517

Oehmichen K, Demant B, Dunger K, Grüneberg E, Hennig P, Kroiher F, Neubauer M, Polley H, Riedel T, Rock J, Schwitzgebel F, Stümer W, Wellbrock N, Ziche D, Bolte A (2011) Inventurstudie 2008 und Treibhausgasinventar Wald (Inventory Study 2008 and Green House Gas Inventory for Forests), Johann Heinrich von Thünen-Institut, Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei (vTI), Institut für Waldökologie und Waldinventuren, Landbauforschung – vTI Agriculture and Forestry Research, 343 p

Seintsch B (2010) Holzbilanzen 2006 bis 2009 für die Bundesrepublik Deutschland (Wood Bilances 2006 to 2009 for Germany), Arbeitsbericht des Instituts für Ökonomie der Forst- und Holzwirtschaft, Johann Heinrich von Thünen-Institut, Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei

Sloboda B (1971) Zur Darstellung von Wachstumsprozessen mit Hilfe von Differentialgleichungen (Presentation of growth processes with differential equations). Mitt. d. Baden-Württemberg. FVA Nr 32. 109 p

Sloboda J, Gaffrea D, Matsumura N (1993) Regionale und lokale Systeme von Höhenkurven gleichartiger Waldbestände (Regional and local systems of height curves for stands). Allgemeine Forst und Jagdzeitung 164:225–228

Tomppo E, Gschwantner T, Lawrence M, McRoberts R (eds) (2010) National forest inventories—pathways for common reporting. Springer, Heidelberg 612