Chapter 32
Norway

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32.1 The Norwegian National Forest Inventory

32.1.1 History and Objectives

The Norwegian National Forest Inventory (NFI) has been producing large-area forest resource information since 1919, as the world's first operational NFI. The first inventory was carried out from 1919 to 1930 (Landsskogtakseringen 1933). The main reason the inventory started at that time was due to concerns about the status of forest resources and the fear of a lack of forest resources in the future. Experience from regional inventories in Norway and Sweden was the basis for the first inventory. Although a lack of forest resources is no longer a major issue of concern, the NFI is still to a high extent used to assess availability of wood at regional and national level, in addition to international reporting (including carbon reporting), bioenergy and biological diversity issues and various research projects.

Over time, the NFI has gradually developed, as new designs and new variables have been introduced according to new scientific knowledge and new requirements. For example, the assessment of coarse woody debris and several ecological variables were introduced in the 1990s. Additional variables and adjustments to facilitate reporting of activities and carbon uptake and emissions from the LULUCF sector were introduced step-by-step from about 2005 until today. Prior to 2005, forest was assessed in the field according to the national definitions only, but from the 1990s with some additional variables to facilitate the reporting of forest area according to the international definitions. Since 2005, forest is directly assessed in the field according to the international definition to facilitate international reporting, while at the same time the national definition is maintained.

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32.1.2 Sampling Methods and Periodicity

Ten inventory cycles have been completed to date, the last one taking place from 2010 to 2014. From the beginning in 1919 until the mid-1950s, the surveys were organised as strip-sampling inventories and later on as plot sampling inventories with temporary plots only.

From 1986 to 1993, fixed-area circular permanent sample plots were installed in all counties except Finnmark. This inventory cycle, NFI6, was carried out on a county-by-county basis. In 1994 the concept of continuous forest inventory was introduced, with 20 % of the sample plots inventoried each year. Since 1995, inventories have been carried out together on a county basis with re-measurement of the permanent plots in such a way that temporary plots have been measured in selected counties and completed over a 5-year period. The temporary plots are, however, not relevant for international reporting and for preparation of statistics at the national level.

Limited inventory work in Finnmark, the northernmost county, was started in 2005, and the first cycle was completed in 2011. Afterwards, the permanent plots in Finnmark are re-measured according to the same system as in other counties. Also, during the period 2005–2009 the low productivity mountain forest was assessed for the first time. That means the development of the entire forest area, its growing stock and its biomass can now be monitored. Efforts have also been made to assess the land-use class of all sample plots in the national grid, and to track all land-use transitions of sample plots. This is an important requirement for the assessment of afforestation, reforestation and deforestation in the LULUCF reporting context. Plots in land-use classes not eligible for tree measurements are normally classified by means of aerial photo-interpretation.

The field sampling intensity for permanent plots is basically the same over the entire country; i.e. one sample plot represents the same forest area regardless of the location of the plot. There are, however, some exceptions in mountain forest and in the far north region. The distance between plots is normally 3 km, both in the north-south and in the east-west direction. If temporary plots used for county wise inventories are disregarded, all plots are installed in a regular grid without clustering. In mountain regions and in Finnmark county the distance is generally somewhat longer and may vary according to strata.

Stand description variables describe the forest stand where the field plot is located. Stand variables are assessed on a 0.1 ha plot around the plot centre (normally circular, but could also have some other shape depending on the location of the stand boundary). If a field plot is divided into two different stands or land use classes, the units are described separately. The minimum size of a partial plot to be described separately is 20 %. For tree measurements, the sample plot is a fixed-radius plot with a radius of 8.92 m (250 m^2). All trees with dbh ≥ 5 cm are measured on the entire plot, regardless of the diameter class. Trees with dbh < 5 cm are counted on four sub-plots inside the sample plot, representing in total 21.2 m^2.

The sampling grid consists of approximately 22,000 plots, of which about 11,700 are located on forest.

32.1.3 Data Collection

The NFI data consist of two main categories: area description and measured tree data. The area data content in broad categories is:

- Administrative data: location (county, municipality), field crew leader, assessment status, etc.
- Site description: land cover and land use class, vegetation type, slope, exposition, site productivity class, soil type, soil depth, bilberry cover, terrain properties, etc.
- Stand properties: stand size, crown storeys, species composition, crown cover, development class, age, damages, browsing by animals, naturalness, etc.
- Accomplished and proposed silvicultural measures: accomplished and proposed cuttings, silvicultural measures, soil scarification, drainage, pruning.

The tree data consist of:

- sample tree data: diameter, species, etc.
- subsample tree data: height, age, diameter, damages, crown density and discoloration (ICP), etc.
- data on deadwood (including decomposition).

Some of the variables are only relevant for "productive forest" and are measured only on plots located within this category. Others are measured for all forests, or for forest and other wooded land. Tree measurements for the assessment of growing stock and biomass are being carried out on all forest and other wooded land, in addition to a few other land-use categories. Complete data for trees outside forest (TOF) or other land with tree cover (OLwTC) are, however, not available.

Further details about the assessments and measurements made in the field can be found in the field instruction manual (Landsskogtakseringen 2014).

32.1.4 Data Processing, Reporting and Use of Results

The estimation of volume statistics consists of three main steps:

1. Estimation of stem volumes for sub-sample trees
2. Generalisation of volumes for sample trees
3. Summary of plot wise area and volume (or biomass) statistics.

Stem volumes of sub-sample trees are estimated with general volume functions using dbh and tree height as regressors (Bauger 1995; Braastad 1966; Brantseg

1967; Vestjordet 1967). Volume estimates are generalised for sample trees by calculating an average tariff (diameter-height relationship) for each sample plot and the occurring tree species group. Approximately 10 sample trees per sample plot are selected, when feasible. The average tariff is then used to estimate the volume of sample trees. When the volume of each tree is known, a height corresponding to this volume can be estimated for each of the sample trees. After these calculations, the following data are available in the database:

- Measured diameter and measured height of sub-sample trees;
- Measured diameter and estimated height of sample trees;
- Calculated volume of all trees.

Measured diameters, together with measured or estimated heights, are used to estimate the biomass of all trees.

The area represented by a sample plot is estimated by dividing the country land area by the number of sample plots. The land area is taken from the official statistics maintained by the Norwegian Mapping Authority. The area estimate for an arbitrary stratum is simply the sum of the areas represented by the number of sample plots within the stratum. If a sample plot is divided into two different stands or land-use classes, the represented area is distributed proportionally between the parts falling into each stand.

For each tree, the corresponding value per hectare can be estimated. The total volume estimate for an arbitrary stratum is obtained by multiplying the tree wise volume estimates per hectare by the area represented by the sample plot, then summing up for all plots in the stratum. Normally the volume represented by each tree and each sample plot is calculated and available in the database, so that the volume for a stratum or a group of trees can be performed by a simple summation.

Change estimates are obtained from the assessments of two consecutive inventories. The volume increment is calculated as the difference between the stem volume on the second occasion, and the volume one year earlier. That is accomplished by dividing the dbh difference of an individual tree by the number of growth seasons (approximately 5) between measurements. The volume tariff (diameter-height relationship) is assumed to be the same on the second occasion and one year earlier. Normally a value for volume increment is assigned to each individual tree on the second occasion, and a summary made to represent all trees inside a stratum or a region. For certain purposes, the volume of trees that have passed the minimum dbh-threshold between measurements are included in the increment estimate, resulting in a more complete estimate comprising all dbh classes. The accumulated volume of these trees provides an accurate estimate of the increment of trees below the dbh threshold.

The level of drain, consisting of the two components harvest and natural losses, can also be estimated by comparing data from two consecutive inventories. However, since the sample is small and variations are significant, reliable annual estimates cannot be provided from the NFI alone.

The results from the NFI are presented at various geographic levels. The smallest unit, for which reliable results can be given, is usually the county level. For bigger counties, the permanent plots will normally provide results of satisfactory quality, but for the smaller counties these data have to be supplemented by data from temporary plots. Results are published in reports presenting the most frequently requested data, for individual counties, regions or for the whole country.

The results of the Norwegian NFI are, to a bigger or smaller extent, used as basis for decision-making in forest policy, forest management, forest products industries, and for evaluating the consequences of decisions taken. Reporting obligations for many international processes and organisations are fulfilled using NFI data and results. Reporting processes include: the Forest Resources Assessment (FRA) of the Food and Agriculture Organization of the United Nations (FAO), the national reports on Land Use, Land-Use Change and Forestry (LULUCF) under the United Nations Framework Convention on Climate Change (UNFCCC) and under Article 3.3 of the Kyoto Protocol, and the indicators and criteria for sustainable forest management in Europe (FOREST EUROPE, UNECE and FAO 2011).

NFI data are utilised as a data source for various research and development projects. Examples include: (i) a study on the possible influence of nitrogen and acid deposition on forest growth (Solberg et al. 2004); (ii) assessment of emissions and removals of CO_2 in forest (Nilsen et al. 2008); (iii) an evaluation to what extent afforestation may be a useful climate change mitigation measure (Haugland et al. 2013); (iv) assessment of the potential for using harvest residues for bio-energy (Bergseng et al. 2013); (v) analyses of the availability and future potential supply of forest resources from the coastal regions (Granhus et al. 2011). The data are also used as calibration and reference data for remote sensing projects, like recent projects on photogrammetry or 3D SAR applications.

32.2 Land Use and Forest Resources

32.2.1 Classification of Land and Forests

32.2.1.1 General Land Classification

Since 2005, the inventory system has been adjusted to facilitate international reporting, while at the same time maintaining the traditional national definitions. Forest is divided into two separate categories; productive forest and non-productive forest (Table 32.1). Together, these two categories normally correspond to the international definition of forest. However, there are a few other adjustments that are normally carried out to accommodate to the international definition. The NFI has specified a minimum area of forest and other wooded land of 0.1 ha, and a minimum width of linear formations of 4 m. Sample plots located on forests between 0.1 and 0.5 ha (or linear formations narrower than 20 m) are identified by

Table 32.1 Land use classes and forest area (2009–2013) from the NFI

Class name	Area (1000 ha)	Comment	Corresponding FRA classes (FAO 2004)
Productive forest	8658		Productive and non-productive forest generally correspond to FAO forest, except from some minor adjustments as described in the text.
Non-productive forest	3522		
Other wooded land	2087		FAO OWL
Barren land, bare rocks	14,201		FAO OL
Cultivated pasture	228	May have some tree cover	FAO OL, OlwTc
Agricultural land	931		FAO OL, OlwTc
Calluna spp. heath	194	Heathlands in coastal districts, historically managed by burning and pasture use.	FAO OL
Other land	614		FAO OL, OlwTc
Inland water	1944		
Total area	32,378		

Figures are not adjusted for minimum forest unit or for current land utilisation

a special variable and can be excluded for international reporting. Plots classified as forest, but located under power lines, land designated for holiday cabins, public roads, railways, etc. are normally also excluded. Finally, small openings in the forest related to infrastructure, landing sites, etc. are not classified as forest according to the national NFI methodology. These plots are reclassified and added to the forest area for international reporting. In total, these adjustments do not have any substantial impact on the area of forest. According to the most recent data, the sum of productive and non-productive forest is 12.180 million ha without adjustments, and 12.104 million ha with the aforementioned adjustments.

32.2.1.2 Forest Classification by Use

In addition to the basic land use classification listed in Table 32.1, each of these classes can be divided into maximum nine sub-classes of current land utilisation. These classes are:

- Forestry (no specific restrictions)
- Urban area, built-up land

- Area designated for holiday cabins
- Recreational area (not necessarily official designation)
- Military training field
- Nature reserve, national park
- Road, railway, airfield (non-forest road)
- Power line
- Other.

The term “productive forest” only means that the area has a productive capacity of at least 1 m^3 per ha and year. This type of forest can also e.g. be located in a nature reserve. To estimate how much is available for wood supply, “productive forest” has to be combined with the current land utilisation “forestry”. Under this limitation, the area is reduced from 8.658 million ha to 8.344 million ha. As some of the productive forest has poor access and/or a stocking of low quality, the actual forest area where wood harvesting is taking place will be less. Non-productive forest and other wooded land are normally not utilised for harvesting wood, although there may be some occasional cutting of firewood and other small-scale harvesting.

Protective forest that is productive, is normally available for wood supply, although with certain restrictions. Such restrictions may be to avoid large clear-cuts, or to practice selective felling. Protective forest is currently not a part of the NFI dataset, and information has to be derived from other sources, if needed.

The rule is that all forest plots should be visited in the field, whenever feasible. There are 27 inaccessible plots (including plots in military forest) in the productive forest and 117 plots in non-productive forest, representing 1.4 % of the total forest area. The majority of plots on other wooded land are also visited in the field. If photo interpretation and data from previous inventory shows that there are no trees of measurable size (≥5 cm dbh) on OWL, the sample plot may not be visited, but classified from aerial photographs. This is the case for plots representing 35 % of the total area under this category.

32.2.1.3 Classification by Ownership Categories

There is currently no complete classification of ownership directly linked to the NFI plots. It is possible to classify most of the plots (80–90 %) by using information from the cadastre and public registers. The completeness of data will probably improve over time.

The following distribution of forest land by ownership categories are taken from Statistics Norway, the national statistics office (Table 32.2). As the data are not totally harmonised with the NFI, the sum of the area categories does not correspond exactly to what is obtained from the NFI. The categories “common forest” and The Finnmark Estate represent community-owned forest and are normally included under private ownership.

Table 32.2 Productive, non-productive and total forest area by ownership classes (1000 ha)

Ownership category	Productive forest	Non-productive forest	Total forest area
Individuals	5668	2284	7952
Other private	267	96	363
Common forest	182	40	221
The Finnmark Estate	59	1047	1106
Municipality and county	218	56	274
Central government	633	580	1214
Unknown	28	29	56
Total	7055	4132	11,186

32.2.1.4 Forest Management and Cutting Systems

According to NFI data, nearly half of the forest area available for wood supply is considered even-aged, while the rest is uneven-aged. This feature is assessed for productive forest, with the exception of temporarily unstocked forest and young stands. If all stands falling into the two latter categories are considered even-aged, the percentage of even-aged stands would be about 55.

Clearfelling is the predominant cutting system. Every year an assessment is carried out on a representative number of sites where harvesting took place three years earlier. The latest assessment (Granhus et al. 2013) reported that on 65.5 % of the harvested area, clearfelling was used. Seed tree cutting was used on 21.7 % of the area, while shelterwood cutting and various types of selective felling were used on the rest of the harvested area. The same assessment concluded that 53.5 % of the sites had been regenerated by means of planting, 7.6 % by a combination of planting and natural regeneration, 27.1 % by natural regeneration and that 11.8 % was insufficiently prepared for regeneration. Results from the assessment for previous years show similar distributions.

Results from the NFI show that 70 % of the harvested volume has been felled in clearcuts, while about 15 % was harvested by selective fellings. Thinnings represented 11–12 % of the harvested volume. Harvesting as a result of land-use changes amounted to slightly above 3 %.

Through the Forestry Act, forest owners are required to provide for satisfactory regeneration, normally within three years after harvesting. However, due to climatic and other local conditions five years is also considered acceptable in certain instances (Skogbrukslova 2005).

32.2.1.5 Legal and Other Restrictions for Wood Use

The provisions of the Forestry Act (Skogbrukslova 2005) require that forests are managed according to the principle of sustainable management. Specifically described is the duty to take appropriate environmental considerations, to provide for satisfactory regeneration and to prevent damage to forests. Forestry operations are generally not permitted in nature reserves and national parks. In landscape protected areas, forest operations can normally be carried out, but with certain restrictions. Also a number of other circumstances may prevent, or significantly reduce, the availability of wood resources in an area with forest cover. Smaller forest patches inside or close to residential areas may be managed for recreation rather than for wood production, although not always with a formal designation. In an area with a high concentration of holiday cabins, it may be more important to preserve the scenic features and to maintain an attractive recreational area.

For more than ten years, environmental assessments (Baumann et al. 2002) have been an integral part of forest management planning. Selected key habitats (currently about 70,000) are to be managed in such a way that their environmental qualities are being maintained. This process is related both to forest certification and to enforcement of public regulations.

A rather complex issue is to what extent the forest formally available for wood supply actually is or can be used for wood production. Some forests are located on steep slopes and/or far away from a road, others may be of low productivity or include trees with inferior quality wood. Cable logging equipment has been used in a number of regions, but to a limited extent, as it makes harvesting significantly more expensive. Data from the NFI and previous studies (Aalde and Gotaas 1998) indicate that roughly 20–30 % of the productive forest and about half of the total forest area can be considered unprofitable for wood extraction.

32.2.1.6 Further Classification of Forests

For national and international reporting, forests are commonly classified into classes according to the dominance of tree species: spruce-dominated (34 %), pine-dominated (28.5 %) and forests dominated by broadleaved trees (35.5 %). Temporarily unstocked forest represents 2 % of the forest area. This distribution was calculated from the productive forest area which is formally available for wood supply. A more detailed grouping of the forest area, covering also less frequently occurring tree species, is shown in Table 32.3. This classification is based on the percentage of individual species on every sample plot, as classified by the NFI during the field survey. Temporarily unstocked forest areas are excluded due to the absence of tree species.

It is obvious that birch is by far the predominant broadleaved tree species. It spreads quickly and is often dominant in young stands before cleaning-thinning. It is also covering extensive forest areas at higher elevations.

Another very common type of classification is by development classes. This classification takes into account site quality, in addition to stand age. Site quality is defined as the dominant tree height at the age of 40 years on a location. The development class furthermore corresponds to a certain age interval for every site quality class. The system is used and defined for productive forest, and may be used both for even-aged and uneven-aged forest. In the latter case, the dominant layer of the forest should be decisive.

Table 32.3 Productive forest area available for wood supply by tree species (NFI 2009–2013)

Tree species	Forest area (1000 ha)	Area (%)
Norway spruce *(Picea abies)*	2683	32.8
Introduced spruce and fir (*Picea* spp., *Abies* spp.)	49	0.6
Scots pine *(Pinus sylvestris)*	2217	27.1
Introduced pine and larch (*Pinus* spp., *Larix* spp.)	16	0.2
Birch (*Betula* spp.)	2577	31.5
Aspen *(Populus tremula)*	131	1.6
Oak *(Quercus robur)*	57	0.7
Rich deciduous forest	57	0.7
Grey alder *(Alnus incana)*	164	2.0
Other broadleaves	229	2.8

The various development classes are defined as follows. Figures in brackets are valid for broadleaved stands, the others for coniferous:

- Class 1: Temporarily unstocked forest land (may have some seed trees or other individual trees)
- Class 2: Young forest. Include forest stands up to the age of 20 (15) years on the best site classes, and up to 55 (30) years on the poorest
- Class 3: Younger production stands. Include forest stands up to the age of 40 (25) years on the best site classes, and up to 85 (55) years on the poorest
- Class 4: Advanced production stands. Include forest stands up to the age of 60 (40) years on the best site classes, and up to 120 (80) years on the poorest
- Class 5: Mature forest: Include forest stands over the age of 60 (40) years on the best site classes, and over 120 (80) years on the poorest (Table 32.4).

32.2.2 *Wood Resources and Their Use*

32.2.2.1 Growing Stock, Increment and Drain

The estimates of growing stock and annual increment are based on measurements of sub-sample and sample trees on the sample plots. According to the national

Table 32.4 Productive forest area available for wood supply, by development classes (NFI 2009–2013)

Development class	Forest area (1000 ha)	Area (%)
Class 1	164	2.0
Class 2	1416	17.0
Class 3	1662	19.9
Class 4	1794	21.5
Class 5	3308	39.6
Total	8344	100

tradition, growing stock and increment are normally estimated and reported under bark. However, growing stock is estimated both under and over bark by the NFI, and both results can be provided. Statistics on increment have to be adjusted by using a fixed bark percentage if increment over bark is required.

National functions used by the NFI give the volume of stem above stump, up to a top diameter of 0 cm, including or excluding bark (Bauger 1995; Braastad 1966; Brantseg 1967; Vestjordet 1967). Branches are not included. The minimum dbh for national purposes is traditionally 5 cm. Since a simplified procedure for estimation of trees with dbh between 0 and 5 cm has been implemented, results are sometimes reported down to 0 cm dbh. Dead trees are not included in the volume estimates unless explicitly specified. Usually increment is calculated such as one year's increment is assigned to every tree with dbh ≥ 5 cm on the second occasion. This is estimated as a mean value of the increment between two surveys of the NFI. Trees not present (or not measurable) on the first occasion are given a value based on an average of similar trees in the same stratum. The ingrowth of trees with dbh below 5 cm is for some purposes added to the sum of the increment of individual trees to obtain a more realistic value of the total increment.

Forest drain consists of the volume of harvested trees and volume of trees that have died during the period between two inventories. It can be assessed by calculating the volume of trees that was present during the initial inventory, but classified as harvested or dead during the subsequent NFI, then adding an increment corresponding to half of this period. An average estimate over a number of years can be made, but as the sample is relatively small, it is not possible to create annual estimates or to analyse in detail the harvest or mortality of various tree species.

There are no official national definitions of drain and increment, but they are more based on custom and tradition. The NFI has also a leading role in defining various forest variables that are often adopted by other institutions.

The NFI also provides biomass estimates, primarily related to LULUCF reporting for the UN Framework Convention on Climate Change and the Kyoto Protocol, but they may also be used for assessment of biomass for bioenergy. A set of Swedish functions (Marklund 1988) for estimation of the various biomass components of individual trees is normally used.

The total growing stock on all forests in Norway is 1070 million m^3 over bark (2010), of which the majority (90 %) is located on productive forest land where harvesting is permitted. In addition, there is about 90 million m^3 of deadwood, of which standing deadwood represents 35 % and lying deadwood 65 %. The annual total increment (over bark) on productive forest land is approximately 29 million m^3. The total drain has been estimated at slightly above 16 million m^3, whereas the harvested volume amounts to almost 13 million m^3. That means there is an accumulation of stemwood, corresponding to between 1 and 2 % of the total growing stock every year. The harvest level has been reasonably constant for about 100 years, while the increment was increasing most of this period. However, over the last 10 years, the increment level seems to have been fluctuating somewhat more. A higher proportion of the increment of spruce is harvested, compared to pine and broadleaved trees.

The growing stock assessed according to the species classification used in the NFI is presented in Table 32.5. As the three most common species: *Picea abies, Pinus sylvestris* and *Betula pubescens*, represent 90 % of the growing stock and similar amount of increment, it is obvious that other tree species play a relatively minor role in wood supply.

Table 32.5 Growing stock on all forest land, by tree species 2010

Tree species	Growing stock over bark (1000 m^3)	Annual increment over bark (1000 m^3)
Norway spruce (*Picea abies*)	439,768	14,988
Scots pine (*Pinus sylvestris*)	317,757	6966
Downy birch (*Betula pubescens*)	181,536	4052
Aspen (*Populus tremula*)	18,789	481
Grey alder (*Alnus incana*)	18,479	786
Rowan (*Sorbus aucuparia*)	10,096	312
Goat willow (*Salix caprea*)	9824	424
Oak (*Quercus robur*)	9568	242
Silver birch (*Betula pendula*)	9126	338
Other *Picea spp.*	6834	417
Ash (*Fraxinus excelsior*)	2961	108
Black alder (*Alnus glutinosa*)	2266	62
Abies spp.	1803	65
Lime (*Tilia cordata*)	1632	40
Bird cherry (*Prunus padus*)	1458	71
Hazel (*Corylus avellana*)	1369	61
Elm (*Ulmus glabra*)	1368	40
Lodgepole pine (*Pinus contorta*)	1058	73
Beech (*Fagus sylvatica*)	943	37
Other conifers	822	34
Norway maple (*Acer platanoides*)	775	27
Larch (*Larix spp.*)	725	27
Sycamore maple (*Acer pseudoplatanus*)	580	28
Other broadleaves	375	13
Yew (*Taxus baccata*)	37	1
Sweet cherry (*Prunus avium*)	20	1
Crab apple (*Malus sylvestris*)	20	1
Other *Sorbus spp.*	11	–
Common holly (*Ilex aquifolium*)	7	–
Total	1,040,007	29,693

Trees with dbh ≥ 5 cm. (1000 m^3)

32.2.2.2 Tree Species and Their Commercial Use

Norway spruce is by far the most important tree species for industrial production. According to data from Statistics Norway, more than 75 % of the total harvest of wood for industrial production consists of spruce. About 50 % of the industrial spruce harvest is sawnwood, while the rest is pulpwood. Pine represents 20–25 % of the wood harvest for industry, while the proportion of sawnwood is slightly higher than for spruce. Harvest of broadleaved trees represents 1–2 % of the total quantity of industrial wood. Approximately 2–2.5 million m^3 is harvested annually for use as firewood. This amount, however, includes a substantial quantity of wood from broadleaved species, mainly birch.

32.3 Assessment of Wood Resources

32.3.1 Forest Available for Wood Supply

32.3.1.1 Assessment of Restrictions

Firstly, the most important restriction is related to site productivity and forest type. Almost 30 % of the forest is located on shallow soil or has unfavorable climatic conditions, meaning that the potential for wood production is practically zero. This has been defined as non-productive forest. The various restrictions on wood supply in productive forest are mostly related to the land utilisation classes listed in Sect. 32.2.1.2. Furthermore, there are a number of environmental considerations (like key habitats) that may reduce or restrict the harvesting level, but not necessarily exclude it completely.

The assessment of national parks and nature reserves is carried out by combining the location of sample plots with a GIS database, thus classifying plots into the category of protected areas where harvesting of wood is not allowed. The other types of restrictions are mainly assessed in the field. A very limited number of sample plots are assessed by watching the plot location from a distance, by means of aerial photographs or by means of maps.

To assess the plots which are formally available for wood supply, but economically assumed to be unavailable, additional information from the NFI may be used. These variables include distance to the nearest road, slope, site quality and tree species, and a separate classification of areas with specific constraints for wood extraction (e.g. islands, transport across lakes or rivers, areas enclosed by railways).

While results for productive forest without legal restrictions and other restrictions related to land utilisation are normally presented in all reports from the NFI, the assessment of economic unavailability is normally only carried out in special studies, like the previously mentioned Aalde and Gotaas (1998), Granhus et al. (2011) and Bergseng et al. (2013).

32.3.1.2 Estimations

The growing stock on non-productive forest and productive forest with land utilisation different from "forestry" represents about 10 % of the total. In a number of studies, the proportion of forest area, growing stock or maximum sustainable yield assumed to be available for wood supply, taking all restrictions into consideration, has been estimated. Vennesland et al. (2006) concluded that at this time, the potential harvest of industrial wood is 25–50 % higher than the current level. Søgaard et al. (2012) reported that about 31 % of the productive forest area in Norway had moderate to strong environmental restrictions on wood harvesting. A significant part of this area is on lower site qualities and has a correspondingly low stocking. At the same time, moderate wood harvest is allowed in some of the area with restrictions. Thus, a reduction of about 15 % on the availability of growing stock has been estimated. Since this reduction is only due to environmental restrictions, the effect of additional terrain constraints would have to be added.

32.3.2 Wood Quality

32.3.2.1 Stem Quality and Assortments

The Norwegian timber grading association "Norsk Virkesmåling" (NVM) has specified general requirements with regard to the quality of roundwood for sale. These include e.g. the occurrence of rot, knots, reaction wood, crooked stems and annual ring width. The main assortments would be first-class and second-class sawlogs of spruce and pine, and pulpwood of the same species. Furthermore, there are a number of special assortments, usually of high quality, such as veneer logs and logs for poles. Roundwood from broadleaved trees may also be classified into similar categories, although the harvested quantity is currently small. The detailed requirements, including minimum and length of logs, are normally specified according to local agreements. The allowable length of logs is normally between 3 and 6 m, but there may be local deviations from this. Cutting of the stem into lengths is today mainly accomplished in a semi-automatic way, in that a computer program in the harvester will propose an optimal division of the stem. Energy wood is a separate assortment.

32.3.2.2 Assessment and Measurement

The NFI does currently not assess stem quality or assortments. There was such an assessment for several years, but it was discontinued in year 2000. The classification at that time was rather simple. For conifers: "Normal quality", "special quality" and "few or no sawlogs". For broadleaves: "Normal quality" and "subnormal quality". These data were not widely used, and it was then concluded that it was difficult to make good estimates corresponding with other timber grading. However this may change if new and more reliable methods are found in the future.

Dead trees, standing and lying, are recorded by the NFI according to five different stages of decomposition. This information may be used to estimate the proportion of deadwood that potentially could be utilised. There are few or no other variables that could be used to assess stem quality.

32.3.2.3 Estimation and Models

The computer model "Avvirk-2000" (Eid and Hobbelstad 2005) allows for creating scenarios of the effect of various forest management options, including allowable fellings, assortment distribution, value of stands and future forest situation. It is based on a theoretical distribution of the stem according to its size, and possible assumptions of a less favorable distribution due to damages must be added separately. The distribution of assortments has been estimated for certain purposes, but is not a part of the normal NFI reporting.

32.3.3 Assessment of Change

32.3.3.1 Assessment and Measurement

The estimation of increment and drain in the Norwegian NFI is based on the field measurements on permanent plots at two consecutive points in time. Sample trees can be distinguished into trees present only at the first occasion, trees present at the first and the second occasion, and trees present only at the second occasion. Sample trees present at the first occasion and that are no longer present on the plot at the second occasion are recorded as harvested or otherwise removed during the field assessment, and the type of stand intervention since the previous survey recorded at the same time. All trees with a dbh ≥ 5 cm are measured according to the same methodology. On sample trees only dbh is measured, while on sub-sample trees both dbh and height are measured. Sub-sample trees are selected using a procedure similar to the relascope, and adjusted such as there will be about 10 sub-sample trees on every plot. A tariff (diameter/height relationship) is then estimated for each tree species on the sample plot, based on data from the sub-sample trees. Using a model, a tree height corresponding to the tariff is finally assigned to each of the sample trees.

32.3.3.2 Estimation of Increment

Normally the increment of individual trees is calculated by using the tariff estimated at the second occasion. Then the diameter difference between the first and the second occasion is used to estimate the diameter one year before the second occasion. The annual increment of a tree is then calculated as the difference between the volume at the second occasion and the volume one year earlier. Standard volume functions are used for this estimation (Bauger 1995; Braastad 1966; Brantseg 1967; Vestjordet 1967). The increment for national reporting is normally calculated only from the trees that were present at the second occasion. The volume of ingrowth trees that have passed the dbh threshold of 5 cm during the period between inventories, are for some purposes added to the total increment of trees with dbh ≥ 5 cm. Volume and increment estimates comprise all parts of the stem above stump height. The increment of trees that have died or are felled between the first and the second occasion is not taken into consideration, as it is assumed to be negligible.

Scaling up from the sample trees to increment per hectare and total increment, is carried out by multiplying with the number of trees represented by the sample trees at the time of the second measurement. The increment can afterwards be aggregated for individual tree species, diameter classes, site classes, development classes, etc., or basically any classification that can be used for grouping of individual trees or sample plots.

The increment obtained by using this procedure gives an estimate of the gross increment. Net increment can be calculated by subtracting an estimate of the annual natural mortality from the gross increment.

Increment in terms of biomass may in principle also be estimated, as the calculation has the same requirement of data (dbh and height) as for volume increment. However, this is not very relevant in our case, since the stock change method is employed for LULUCF reporting.

32.3.3.3 Estimation of Drain

Drain is the volume of trees that have been harvested between two field assessments, plus the volume of trees that have died during the same period. The volume of sample trees that are found to be harvested or dead is calculated by using the tree measurements at the first occasion. The standard functions and normal calculation method for tree volume estimation used at the first occasion are utilised. As the annual increment of individual trees is readily available in the database, an increment corresponding to half the period between the two occasions can easily be added to the harvested volume. The volume of felled trees on areas converted to other land-use classes is included in the drain estimates. Normally the drain is calculated as an average annual figure for the assessment period. Scaling up from the sample trees to drain per hectare and total drain, is carried out by multiplying with the number of trees represented by the sample trees at the time of the second measurement. In principle, the drain can be distributed by tree species, subcategories of forest, etc., however there are some practical limitations due to the rather small sample size. An advantage of assessing the harvest and mortality from NFI data is that it is possible to keep living and dead trees apart to avoid double counting of dead trees. If an already dead tree is harvested, it should previously have been included in the drain and not counted again.

Annual harvesting statistics of industrial wood are published by Statistics Norway. They cover by far the major part of the harvested quantity of wood. However, they have some limitations, in that the harvest of firewood is estimated by means of a consumer survey. Also, self-consumption by forest owner may be inadequately covered by these statistics. These statistics do also cover the removals, not the fellings. To obtain an estimate of fellings from these statistics, harvesting losses have to be added. On the other hand, the figures provided by Statistics Norway give a better picture of the fluctuations from year to year.

32.3.4 Other Wooded Land and Trees Outside Forest

32.3.4.1 Assessment and Measurement

The sampling grid of the Norwegian NFI covers all land-use classes and ownership categories. Since 2005, other wooded land has been assessed according to the international definition (FAO 2012). The measurement of trees on these plots is carried out according to the same methodology as for forest. On OWL plots located in remote areas, the plots are often not visited in the field if it is obvious from the photo interpretation that there are no trees of measurable size (≥5 cm dbh). This means that it is possible for trees below 5 cm dbh not to be assessed. However, this is not of significant importance.

Pasture lands and open areas not under any of the main land use classes are also inventoried according to the normal NFI methodology, with re-measurement at 5 years intervals. Agricultural lands and urban areas/built-up land were subject to a trial assessment about five years ago, when a sub-sample of the total number of plots under these categories was assessed. This assessment included visiting private gardens for detailed tree measurements. The measurements on agricultural lands and urban areas/built-up land have not been completed and were discontinued.

32.3.4.2 Estimation

Calculation of growing stock and increment on OWL and other land-use classes corresponds to the methodology described for forest. The area of other wooded land is given in Table 32.1. Total growing stock on OWL has been estimated at 7 million m^3, which is about 0.7 % of the growing stock in forest.

Based on the assessments a few years ago, the growing stock of the other land categories outside forest have been estimated at:

- Open areas + pastures: 4.8 million m^3;
- Agricultural land: 1.6 million m^3;
- Urban area/built-up land: 5.3 million m^3.

In total, the latter categories represent nearly 12 million m^3, which is about 1.1 % of the total growing stock in forest. Altogether, the growing stock of trees on land not classified as forest is hardly more than about 2 % of the growing stock in forest.

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