Chapter 34
Portugal

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34.1 The Portuguese National Forest Inventory

34.1.1 History and Objectives

In Portugal, the first forest area evaluation dates back to the late XIX century, which predates the first NFI. Monteiro (2007) refers that in 1874 Gerardo Pery estimated a total forest area of 640,000 ha, which represented 7.3 % of the country mainland area. In subsequent decades, updated evaluations were published, namely in 1902 and 1928 by Mendes de Almeida and in 1956 by SROA (former Portuguese service for land planning), revealing a very significant increase in the Portuguese forest area. In 1956 the total forest area was 2.763 million hectares, corresponding to 31.0 % of Portuguese mainland area. The first evaluation to include a biometric characterisation of forest stands based on the measurement of a sample of field plots took place during the years 1965–1966, and was conceived as the first Portuguese National Forest Inventory (DGSFA 1965–66, 1966). Since then, four NFIs have taken place, and a new NFI (NFI6) is currently on-going. The sequence of the six Portuguese NFIs, detailing the time periods corresponding to land cover and field data collections, is presented in Table 34.1.

Since NFI5, the Portuguese NFI includes not only data for the mainland territory but also for Madeira's and Azores' Autonomous Regions. These two atlantic

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Table 34.1 Dates for the land cover and field data collections of the six Portuguese national forest inventories

NFI	Designation	Reference year	Land cover data collection period	Biometric field data collection period
NFI1	National forest inventory	1965	1965	1965–1966
NFI2	1st NFI revision	1974	1968–1980	1968–1980
NFI3	2nd NFI revision	1985	1980–1989	1980–1989
NFI4	3rd NFI revision	1995	1995	1997–1999
NFI5	5th National forest inventory	2005	2004–2006	2005–2006
NFI6	6th National forest inventory	2015	2010–2015	2014–2015

archipelagos have their own forest inventory programmes, which were initiated more recently. To date, the Azores had one single forest inventory (IFRAA in 2007) and the Madeira's has just concluded the second forest inventory (IFRAM1 in 2010 and IFRAM2 in 2015). The contribution of Azores and Madeira's to Portuguese forest area is relatively small, since these territories represent to approximately 3 % of the nation's terrestrial area. But the presence of "Laurissilva" subtropical forest, a pristine forest that represents the world's largest remaining area of the Tertiary forests that covered most of the south of Europe and the North of Africa (Capelo 2004), is a relevant aspect on Portugal's forest statistics.

All NFIs include estimations of forest area, based on data extracted from aerial photography by photointerpretation techniques, and the characterisation of the stands of the most representative tree species in the country. The NFI methodologies have evolved over the years to adapt to the needs of the forest industry and to national and international reporting requirements. NFIs use a land use/land cover nomenclature that has been modified through time. However, this evaluation has always included an assessment of: forest land use, forest composition with the identification of the two most abundant tree species, and crown cover classification. The forest and other wooded land definitions of the Food and Agriculture Organization of the United Nations (FAO 2004) have been used since NFI4. In the earlier NFIs, areas of forest strata, that included also stand structure, were evaluated based on photointerpretation of aerial photographs and resulted in the production of cartography. At that time, aerial photographs were captured by region. A wall-to-wall forest cartography at 1:25,000 scale is available for NFI2 (1968–1980), but photographs correspond to different time periods. The high dynamics of the Portuguese forests, due to a high incidence of wild fires and a significant increase of new plantations, justified the need to use whole country aerial photographs obtained in a single year. A more expedite methodology for forest area estimation was used, based on qualitative sampling, that enabled an estimate of forest strata areas closer to photography's data. The first full coverage of aerial photography was taken in 1990, followed by the aerial coverages taken in 1995,

2005 and 2010. Forest areas in 1995 were based on a sampling grid different to the one used in 2005 and 2010. The national commitment to consistently report the activities in land use, land-use change and forestry (LULUCF) sector led to the reassessing of land use/land cover of 1995 aerial photographs using the NFI5 grid. The current NFI is based on the same grid system, and a consistent time series of land use/land cover data for 1995, 2005 and 2010 is presently available. Within the framework of NFI6 it was possible, and for the first time, to compute land use/land cover transition matrices, which provided a relevant insight into Portuguese land use/land cover dynamics.

All NFIs included the measurement of a sample of field plots in order to characterise the forest stands with the most important forest tree species in Portugal. Standing volume estimation was the main objective of the first four NFIs, as well as the growing stock increment for maritime pine (*Pinus pinaster* Ait.). In the course of NFI4, stand structure was also evaluated taking into account the shrub strata and using vegetation diversity models, the production of non-wood goods such as cork, resin and acorn and the evidence of erosion and fire as well as forest vitality at the stand level (DGF 2001). Biomass and carbon stock estimations as well as volume of standing dead trees and shrubland biomass were included for the first time in NFI5 (2005–2006).

The scope of the current inventory (NFI6) has increased, with the following topics included within its framework: habitat identification and conservation status evaluation; soil characterisation and organic carbon evaluation; comprehensive deadwood evaluation for biomass and carbon quantification; shrubland species identification and carbon stock quantification; alien and exotic species quantification; and tree growth data collected with increment borers for biometric model development.

More detailed descriptions of the Portuguese NFIs can be found in the original reports that are listed on pages 231–233 of the NFI4 official report (DGF 2001 – in Portuguese) in the NFI5 report (AFN 2010) or in Tomé et al. (1997) and Barreiro et al. (2010).

34.1.2 Sampling Methods and Periodicity

The Portuguese NFIs occur in an approximately 10 year cycle (Table 34.1), and a new inventory (NFI6) is presently on-going. The first four NFIs were based on temporary sample plots. However, the importance of monitoring changes in the forest resulted in the establishment of a permanent sampling grid system during the NFI5 (2005–2006) increasing the photointerpretation sampling intensity from ca. 130 thousand points in 1995 to ca. 360 thousand points in 2005. This grid system is based on a 500 × 500 m grid that is used for photointerpretation and includes sub-grids of 2 × 2 km and 4 × 4 km that are the basis for field work in forests and shrubs, respectively. Temporary sample plots were concentric fixed-area circular plots with areas of 250, 500 and 1000 m^2, according to tree diameter at breast

height (dbh) thresholds of 7.5, 17.5 and 27.5 cm, respectively. In NFI5, after realising that a large percentage of the Portuguese forests is even-aged, simple fixed-area circular plots were adopted, with an area of 500 m^2 for wood production species and 2000 m^2 for cork and holm oaks stands. In steep-sloped terrain, where trees are planted in terracing systems, special rectangular plots covering two terraces and a length adjusted in order to achieve an area of 500 m^2 were used. In all NFIs a cluster of five 10 m^2 plots (40 m^2 plots in cork and holm oaks), centred at the plot centre, was used to count trees below the dbh threshold of 7.5 cm (5 cm for *Eucalyptus* spp. since NFI5). The plot was considered to be part of a forest stratum, if the centre of the plot coincided with this forest stratum. When plots do not fully occur within the forest stratum, an estimation of the fraction of the area matching with the target stratum is made in the field. In NFI5 field plots were assessed on a 2 × 2 km grid that corresponds to 22,091 points of which 12,258 were classified as forest or shrubs. In the case of shrubs, only plots located on the 4 × 4 km grid were measured. In the previous NFI's the number of plots measured in the field was smaller (e.g. Barreiro et al. 2010).

34.1.3 Data Collection

This section focuses on the data collected in NFI5. The most important improvements implemented in NFI6 are also described. Besides basic data such as the plot coordinates, allocation of sample plots to administrative regions, land use, date of measurement, verification of the land cover photointerpretation, the Portuguese NFI assessed five main categories of variables: site, stand, plot, trees within the plot and sample trees.

To assess site conditions influencing the growth and development of trees and stands, site variables such as land use/land cover, elevation above sea level, terrain aspect, slope gradient, terrain location and soil erosion are considered. In order to characterise the forest stand where the sample plot is located, the two main species are identified and their structure, age class and method of age determination are registered. The stands' vertical structure, including shrubs, is assessed by estimating percent cover according to height layers. The species richness (area and number of species), the understory use (e.g. grazing, agriculture) and the percent cover of litter and respective thickness are also collected. Recent stand treatments (pruning, weeding, thinning, cork extraction, forest roads maintenance), the occurrence of harvesting and the percentage of trees removed during harvesting if not clear-cut and the cutting cycle (only for species managed with a coppice system) are assessed as well as the occurrence of tree tapping (pine resin), lichens presence and tree vitality. The occurrence of fire, year of fire and type of damage (partial or total) along with the Northern Forest Fire Laboratory fuel model identification. Finally, for the dominant and secondary species regeneration evidence and type (natural,

planting, seedling or coppice) are recorded as well as, in plantations, the spacing (distance between and within plantation lines) and any evidence of site preparation.

At plot level, the plot shape and its size (500, 2000 m^2 or a fraction of those areas) are recorded along with the plot land-cover (same as the stand, forest gap, clump of other species, clearcut, burnt).

All trees within the plot and above the dbh threshold have two perpendicular dbh measurements recorded and the following variables are assessed: species; tree status; tree shape; tree health evaluation (classes of decolouration and defoliation); tree development stage classes (Kraft); tree age in even-aged stands (younger, equal or older than the stand); Boolean indicator variables for dominant limit trees and standing dead trees. Additional variables specific for cork oak trees are collected: year, type and debarking level, evidence of excessive pruning, excessive grazing or of inner-bark wounds.

Additional measurements are carried out for sample trees (per 5 cm dbh class, the tree with dbh closest to the class mid-point): two perpendicular diameters at stump level; tree height; height to the living crown base; tree age with an increment borer (for even-aged softwood stands in two of the dominant trees and in the average tree). Further for cork oak trees also stem height, height of bifurcation, debarking heights, number of 1st and 2nd order debarked branches.

Detailed and further information about the data collected in NFI5 is available in the field protocol (DGRF 2005).

In NFI6, most of the NFI5 variables were considered, but significant improvements were included at methodological level, namely by the inclusion of new variables and by an in-depth revision of NFI conceptual framework and data gathering procedures. A publication containing a detailed description of the biometric data gathering procedures for vegetation used in NFI6 will soon be made available to the public.

34.1.4 Data Processing, Reporting and Use of Results

In the Portuguese NFI, area estimates are obtained by qualitative sampling, based on the land use/land cover classification of the set of 360 thousand photo-points (500 × 500 m grid) using photointerpretation techniques. Land Use Maps and Stand Type distribution Maps for continental Portugal were produced (DGF 2001). The area of the Portuguese territory, and the administrative NUTS regions were obtained from the official cartography of Portugal (*Cartografia Administrativa Oficial de Portugal*—version 2009.0).

Field assessments and measurements in plots located at each point of the 2 × 2 km or of the 4 × 4 km grids, for forest and shrub plots respectively, were the basis for the estimation algorithms used to evaluate stand characteristics in NFI5. The estimation of the volume and biomass of standing stock and of growing stock is

of particular interest for productive forest land, but also very relevant for carbon stock and sink evaluation on the whole forest land. The estimation procedure includes several steps, starting with the estimation of tree height for each non-sample tree using species-specific height-dbh curves (DGF 2001; Barreiro et al. 2010). The volume and biomass of each tree within the plot is then calculated using species-specific functions (DGF 2001; Barreiro et al. 2010). Tree volume and biomass estimations are summed up for each plot and expanded to per hectare estimates using the corresponding plot area.

During the inventory process, quality control procedures are applied to check data input and data processing. The consistency of data input is also checked in terms of compliance with the methodology.

Plot estimates per hectare are aggregated for each forest stratum to a mean volume or biomass per hectare and multiplied by the respective area to obtain the total volume or biomass of standing stock and growing stock of each forest stratum. Mean volumes and biomass per hectare and total volumes and biomass are also estimated for the Portuguese mainland as well as for the required administrative regions. Change estimations can be obtained by the use of existing forest regional simulators (e.g. Barreiro and Tomé 2011, 2012).

The Portuguese NFI provides official estimates at national level, NUTSII level, and Regions for Forest Planning (PROF) level. The estimates at NUTSII and PROF levels do not include all the statistics published at the country level due to the small sample sizes that lead to large percent errors. The FloreStat software, available from the internet site of the Portuguese Forest Service (http://www.icnf.pt/portal/florestas/ifn), allows users to obtain more detailed information, for smaller administrative regions (NUTSIII and larger municipalities) regarding the main NFI indicators.

The results of the Portuguese NFI are used as a basis for decision-making processes in forest and environment policy, forest management, forest products industries, and for evaluating the outcomes of the implemented plans and decisions. National reporting commitments with several national and international processes and organisations are fulfilled using the data and results of the Portuguese NFI. The main reporting processes include: the national economics accounts on forests, 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 Articles 3.3 and 3.4 of the Kyoto Protocol, the criteria and indicators for sustainable forest management under FOREST EUROPE process (FOREST EUROPE, UNECE and FAO 2011), the evaluation of conservation status of natural habitat types under the Habitats Directive (Council of the European Communities, 1992), and the United Nations Convention on Desertification reporting. Besides that, NFI data are a valuable data source for numerous research projects, and for outlook scenario analyses to estimate current and future potential of Portuguese forests in wood and cork supply (e.g. Santos et al. 2013).

34.2 Land Use and Forest Resources

34.2.1 Classification of Land and Forests

34.2.1.1 General Land Classification

The land classification system used in NFI5 for photointerpretation (500 × 500 m grid) follows a hierarchical system of land use types (Table 34.2). At the top level, land area is divided into forest and non-forest. Forest is then sub-divided into forest and other wooded land. The non-forest land is presented separately for shrubs, agriculture, other uses and inland waters. The FAO definition of forest is used directly by the Portuguese NFI: land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10 %, or trees able to reach these thresholds in situ. It includes windbreaks, shelterbelts and corridors of trees with an area larger than 0.5 ha and width larger than 20 m. It does not include land that is predominantly under agricultural or urban land use. All other land uses/cover require also a land spanning of more than 0.5 hectares and a width larger than 20 m. The land use types presented in the Portuguese NFI are compatible with the FRA 2015 terms and definitions (FAO 2012). The details of the land classification system applied in NFI5 are described in the photointerpretation manual (DGRF 2006) and the approaches used in NFI6 will be soon made available to the public by the Instituto da Conservação da Natureza e das Florestas (ICNF).

Table 34.2 shows the NFI5 areas for the forest and non-forest land classes, its description and a comparison with the Forest Resources Assessment of FAO (2004) definition. The area of Other Wooded Land (OWL) has been included under forest land, although it has always been estimated separately so it can be discounted from forest area for international reporting purposes. Similarly to OWL, shrubland area which has always been estimated within the NFIs framework, was only reported for the first time under FRA 2015.

34.2.1.2 Forest Land Classification

In NFI5, forest land was classified using a combination of photointerpretation, coupled with the information collected during the measurement of field plots. The photointerpretation registers the forest composition by indicating the main and the secondary tree species as well as the occurrence of other species. The tree species (or tree species groups) considered individually in the Portuguese NFI are: maritime pine (*Pinus pinaster* Ait.), eucalypts (*Eucalyptus globulus* Labill.), cork oak (*Quercus suber* L.), holm oak (*Quercus ilex* L. subsp. *ballota* (Desf.) Samp), other oaks (*Quercus* spp.), umbrella pine (*Pinus pinea* L.), chestnut (*Castanea sativa* Miller). All other species are grouped in one of the following groups: other hardwoods and other softwoods. Since NFI5 (2005–2006) *Acacia* spp. are considered as

Table 34.2 Land use classes according to the national definition and the respective area (NFI5, 2005–2006)

Land use class		Description	Area (1000 ha)	Corresponding FRA classes (FAO 2004)
Forest	Forest area	Production forest, protection forest, recent stands (planted or regenerated by broadcast seeding), sites prepared for plantation, nurseries, shelterbelts, forest roads, gaps, clumps, chestnut and umbrella pine orchards; it also includes burnt and clear-cut areas	3310	Forest
	Other wooded land	Land with tree species that, due to site conditions, will not attain a height of 5 m and land with tree species with a crown cover less than 10 %	148	OWL
Non-forest	Shrub-land	Land with shrubby or herbaceous vegetation, of natural origin, and where no forest or agriculture takes place	1927	(not reported as OWL based on 2004 definition)
	Agricultural land	Cropland, fallow land, horticulture lands, fruit orchards (except chestnuts and umbrella pine), vineyards and grazing land. This land use may contain "trees outside the forest"	2929	OL, OLwTc
	Other uses	Unproductive non-forest land, urban areas	432	OL, OLwTc
	Inland waters	Large rivers, estuaries, lakes, dams, reservoirs, marshes and salt marshes	162	OL
Total land area			8908	

a separate group, and in NFI6 carob trees (*Ceratonia siliqua* L.) were considered as an autonomous forest species.

The occurrence of trees outside forest in the agriculture, shrublands or other uses is also registered for the main species.

Besides species and stand composition, the following characteristics are also registered for forest stands during the photointerpretation: crown cover of forest stands and identification of young stands, burnt stands or recently clear-cut stands; dimension of the stand; and understory use. Crown cover of forest stands is registered using the following classes: <10 % or vegetation that will not attain a height of 5 m (OWL); 10–30; 30–50; >50; young stand; burnt stand; harvested stand (clear-cut). The stand's dimension is evaluated in 4 classes: <2; 2–10; 10–50; >50. The understory use classes considered are: crops (including grasslands); bare soil; low density shrubs (cover <50 %); dense shrubs (cover ≥50 %).

In NFI5 the percentage of stands managed as high-forest and coppice was estimated (but not published) and can easily be made available. Regarding wood resources characterisation, the distinction between productive forest and protective forest is particularly relevant. NFI5 includes the estimation of areas that are within Protected Areas and under the NATURA 2000 program. However, Forest Available for Wood Supply (FAWS) is not estimated as a separate category. All resource-related estimates like standing volume, growing stock, increment and harvest are calculated for the entire forest area.

34.2.1.3 Classification by Ownership Categories

The Portuguese NFI distinguishes forest ownership into two main categories: Private and Public. Public forests are subdivided into National Forests and Other Public Forests. The large majority of the Portuguese forest area is privately owned (97.2 %). Public forest area corresponds to a mere 2.8 % of the total forest area, of which 98.6 % are classified as "Matas Nacionais", i.e. National Forests.

34.2.1.4 Forest Management and Cutting Systems

Forests in Portugal are managed as even- and uneven-aged systems. The respective areas, as a total in the country and by dominant tree species, are estimated using the combination of the information obtained by photointerpretation and the stand structure registered in the field plots. Approximately 60 % of the Portuguese forests are uneven-aged. However the proportion of even-aged stands strongly depends on the tree species. More than half of the maritime pine stands (56 %) are managed as even-aged, while the majority of cork and holm oaks stands (62 and 73 %) are uneven-aged stands. Most of the *Eucalyptus* plantations (65 %) are even-aged stands.

Eucalyptus plantation management does not consider thinnings during the first cutting cycle (high-forest), but includes thinning during the 2nd and 3rd cycles to

reduce the number of shoots regenerated between 2 and 3 years after harvest. Therefore, harvested wood results mainly from clear-cuts. Other even-aged forests, in particular the maritime pine stands, usually incorporate the following silvicultural practices for guiding stand development: stand establishment by natural regeneration or planting, cleaning and pre-commercial thinning, thinning, clear cutting or final cutting of all the remaining trees.

34.2.1.5 Legal and Other Restrictions for Wood Use

The forests in Portugal are predominantly privately owned (97.2 %) and are mainly owned by individuals (89 %). The Law on Forest Policy (Law nº 33/96) establishes that forest harvesting, conservation, land use change and expansion are of Public interest and that the Public Administration is responsible for defining the regulation for the use and fruition of the natural resources.

Therefore, harvesting in stands of wood production species (all, except cork and holm oak) is at the discretion of the forest owner's, but they have to comply with the Portuguese forest legislation, for instance the Decree-Law nº173/88 that inhibits premature cuts of forest stands, and ideally the operation should be foreseen in the respective Forest Management Plan. Harvesting of cork and holm oak stands can only occur due to land use transformation purposes and it requires a *Declaration of Indispensable Public Usefulness*, which is issued by three Ministers. Pruning and maintenance cuts on theses stands, also require authorisation from the Institute for Nature Conservation and Forests (ICNF).

Since 2014, the establishment of new forest areas, larger than 0.5 ha, requires the owner or manager to, depending on site dimension and location, to inform or request an authorisation to (re)plant from ICNF. These procedures will enable the national forest authority to have close to real-time data on human induced forest expansion and to more effectively monitor the degree of accomplishment with the objectives established in National and Regional Forest Plans.

34.2.2 Wood Resources and Their Use

34.2.2.1 Forest Area by Dominant Tree Species

According to NFI5, the main tree species in the Portuguese forests are maritime pine, eucalypts and cork oak (27.9, 23.3 and 22.5 % of the forest stands area, respectively). Note that the Portuguese NFI separates between stand area and forest area as the later includes the temporarily unstocked areas, namely burnt and recently clear-cut areas. The productive forest area and the coverage by the tree species is given in Table 34.3.

Table 34.3 Forest stands area (1000 ha and % cover) by dominant tree species in continental Portugal (NFI5, 2005–2006)

Tree species	Area (1000 ha)	Area (%)	Remark
Maritime pine	885	27.9	
Eucalyptus spp.	740	23.3	
Cork oak	716	22.5	Not reported as FAWS
Holm oak	413	13.0	
Other oaks	150	4.7	
Umbrella pine	130	41	
Chestnut	30		
Acacias	4		
Other hardwoods	82		
Other softwoods	25		
Total forest land	3175		

34.2.2.2 Forest Area by Tree Species, Stand Composition and Age Class

In NFI5 the areas were also presented by age class for even-aged stands (Table 34.4). The large areas of maritime pine and eucalyptus in young age classes are a consequence of the large forest fires that occurred in 2003 and 2005, whereas cork and holm oak stands, not managed for wood production, and less affected by these forest fires, present the bigger areas in the older age classes.

34.2.2.3 Standing Volume, Increment and Drain

NFI5 estimates of standing volume are based on field measurements, combined with the area information. Volumes are defined as stem volume over-bark including stump, and include all trees having dbh > 0. The volume of trees having a dbh greater or equal to 7.5 cm (5 cm for eucalypts), measured over bark, is calculated using species-specific volume equations (AFN 2010). Tree heights for the non-sample trees are also estimated with species-specific equations (AFN 2010). The volume of trees below the 7.5 cm threshold (counted, not measured) is included by estimating the volume of an average tree in each dbh class (dbh < 5 cm and 5 cm ≤ dbh < 7.5 cm), using the dbh of 2.5 and 6.25 cm respectively, the average height measured for the class and a form factor. The average tree volume is then multiplied by the number of trees counted in the five 10 m^2 satellite plots centred at the plot centre. In NFI5, standing volume can be disaggregated into the volume of growing stock and volume of standing dead trees. Increment and drain are not directly calculated from the NFI data. Increment may be estimated for the three most important tree species by using the regional simulators available for the country (Barreiro and Tomé 2011, 2012). For the Kyoto protocol reporting,

Table 34.4 Forest area (1000 ha) by dominant tree species, stand composition and age class (NFI5, 2005–2006)

Species	Stand composition[a]	Age classes (years)							
		<10	10–20	20–30	30–40	40–50	50–60	≥60	Uneven-aged
Maritime pine	Pure	133.67	79.66	59.41	50.41	41.86	19.80	16.65	279.94
	Dominant	15.56	9.33	10.37	16.08	6.22	5.70	2.59	78.82
	Secondary	21.18	12.36	8.24	5.88	5.30	1.77	2.35	61.77
Cork oak	Pure	6.38	6.38	43.52	44.68	15.67	20.31	86.47	324.39
	Dominant	1.39	2.77	4.85	4.85	1.39	3.47	19.41	83.18
	Secondary	5.99	0.80	3.60	2.40	2.00	3.20	7.19	60.32
Holm oak	Pure	0.53	1.59	7.40	13.22	12.16	16.39	53.39	255.84
	Dominant	0.00	0.47	0.47	2.80	0.00	0.93	4.67	36.90
	Secondary	5.49	0.00	2.74	0.00	0.00	2.19	1.10	52.12
Other oaks	Pure	0.77	1.92	4.99	2.68	2.30	1.15	1.53	87.05
	Dominant	0.00	0.00	2.01	1.00	2.01	2.01	0.00	37.16
	Secondary	0.00	1.49	1.49	0.74	0.00	0.00	0.00	54.33
Umbrella pine	Pure	2.10	10.00	8.42	5.79	2.10	2.63	1.05	21.57
	Dominant	0.98	2.95	1.47	2.46	0.49	0.49	0.98	20.64
	Secondary	2.01	3.36	0.67	1.34	2.01	1.34	1.34	30.88
Chestnut	Pure	0.00	4.03	0.00	2.01	2.01	0.00	0.67	15.44
	Dominant	*	*	*	*	*	*	*	*
	Secondary	0.34	0.34	0.00	0.00	0.00	0.00	0.00	3.44
Acacias	Pure	0.00	0.09	0.00	0.00	0.00	0.00	0.00	1.94
	Dominant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.07
	Secondary	*	*	*	*	*	*	*	*

(continued)

Table 34.4 (continued)

Species	Stand composition[a]	Age classes (years)							
		<10	10–20	20–30	30–40	40–50	50–60	≥60	Uneven-aged
Other hardwoods	Pure	0.00	12.50	1.79	0.00	0.00	1.79	1.79	37.51
	Dominant	*	*	*	*	*	*	*	*
	Secondary	*	*	*	*	*	*	*	*
Other softwoods	Pure	0.00	1.81	2.49	1.13	1.13	0.23	0.00	5.20
	Dominant	*	*	*	*	*	*	*	*
	Secondary	*	*	*	*	*	*	*	*
Species	STAND composition	Age classes (years)							
		<4	4–8	8–12	12–16	16–20	≥20	Uneven-aged	
Eucalyptus	Pure	97.31	113.02	98.83	58.79	14.19	10.14	174.34	
	Dominant	6.72	10.64	14.00	11.20	2.24	7.28	40.89	
	Secondary	4.11	9.58	11.64	5.48	0.68	8.21	47.23	

[a]*Pure* Pure stands; *Dominant* Mixed stands with the species as dominant; *Secondary* Mixed stands with the species as the secondary species; *sample size not large enough

Portugal uses average increment values per tree species, when multiplied by the area covered by each species, allow for the estimation of increment (Pereira et al. 2014). Drain is estimated based on information gathered in questionnaires to major forest producers and industrial associations and from the questionnaires to production industries (prodcom database—eurostat) using conversion coefficients calculated from forest inventory and industrial production data.

Besides volume estimation, the Portuguese NFI also estimates total biomass, aboveground biomass, root biomass and biomass by tree components (wood, bark, branches and leaves/needles) using allometric equations available for the country (DGF 2010).

The forest land in Portugal has a standing volume of 182 million m^3 of stemwood overbark of which 5 % corresponds to standing dead wood. Maritime pine is responsible for the majority of the standing volume (47 %), followed by eucalypts (25 %), cork oak (14 %), holm oak (4 %), other oak spp. (3 %) and umbrella pine (2 %). The remaining tree species altogether account for 4 % of the standing volume. Table 34.5 gives the estimates of standing volume and increment by tree species. The increment values are the ones used in the Portuguese National Inventory Report (PNIR) (Pereira et al. 2014).

34.2.2.4 Tree Species and Their Commercial Use

According to NFI5, the main tree species in Portugal are maritime pine, eucalyptus and cork oak which together represent 74 % of the forest area and 86 % of the total standing volume. From those species just maritime pine and eucalyptus, representing 51 % of the forest area and 72 % of the total standing volume, are relevant for wood production, as cork oak is mainly managed as an agroforestry system with cork as the principal product. In 2014 the total supply (removals) of roundwood amounted to 8.2 million m^3 for broadleaves and to 2.7 million m^3 for coniferous

Table 34.5 The volume of standing stock and increment on forest land (NFI5, 2005–2006)

Tree species	Standing volume (1000 m^3)	Increment (m^3 ha^{-1} $year^{-1}$)
Maritime pine	85,756	5.6
Eucalypts	45,828	9.5
Cork oak	24,773	0.5
Holm oak	7566	0.5
Other oaks	5405	2.9
Umbrella pine	4330	5.6
Chestnut	1631	2.9
Acacias	521	2.9
Other hardwoods	4325	2.9
Other softwoods	1639	5.0
Total	181,774	

(UNECE/FAO Timber Database). Eucalyptus is mainly used for paper and paperboard production (45.7 %), raw pulp (29.2 %) and corrugated paperboard (10.1 %), whereas maritime pine has been traditionally used for carpentry and construction (39 %), sawnlogs (26 %), fiberboard and particleboard (14 %) (Santos et al. 2013). More recently, maritime pine wood is also used to produce pellets.

34.3 Assessment of Wood Resources

34.3.1 Forest Available for Wood Supply

34.3.1.1 Assessment of Restrictions

In Portugal, and for reporting processes, the whole forest area is considered as forest available for wood supply, with the exception of cork and holm oak areas in which wood harvest has strict restrictions, the "Laurissilva" forest, and particular conservation areas where harvesting is strictly prohibited.

The field assessments of the Portuguese NFI5 includes all sample plots in the sampling grid, with the exception of plots in inaccessible terrain which are just classified using aerial photographs. The existence of legal restrictions is not assessed in the field, but rather obtained from a post-stratification approach by intersecting sample plot locations with a GIS database that contains the areas with restricted harvest. Any restriction available as geo-referenced GIS-layer can be considered in assessing the forest area available for wood supply.

With regard to other restrictions and in particular to site characteristics that may restrict harvesting, the Portuguese NFI assesses several relevant variables such as accessibility and slope. These attributes are decisive for the use of harvesting and logging technologies.

34.3.1.2 Estimations of Future Wood Availability

The Portuguese regional simulator SIMPLOT that projects national forests into the future taking into account several drivers—wood and biomass demand, forest fires, afforestation and deforestation—was first developed for eucalyptus stands (Barreiro and Tomé 2011, 2012). Subsequently, SIMPLOT was broadened to include maritime pine stands and used in a prospective study for the Portuguese forests that was carried out following a demand from the Portuguese Industry. This study (Santos et al. 2013) covered the period after 2012 (2012–2041 for eucalyptus; 2012–2071 for maritime pine and cork oak) and also projected cork oak stands, using an existing simulator specific for this species, the SUBER model (Tomé et al. 2015). No legal restrictions were used for wood harvesting. Restrictions on the establishment of new eucalypt plantations were introduced, by not allowing plantations of this exotic tree species in Natura 2000 areas.

34.3.2 Wood Quality

34.3.2.1 Stem Quality and Assortments

Wood assortments were considered for maritime pine and eucalyptus in NFI5. For maritime pine the assortment includes diameter classes and assortments according to the top diameter and the log length. The classification comprises three classes: class A—logs with a top diameter >20 cm and log length >2 m; class B—log with a top diameter between 12 and 20 cm or >20 cm with a log length <2 m; class C—logs with a top diameter between 6 and 12 cm. For eucalyptus the assortment just computes wood with a top diameter >6 cm.

34.3.2.2 Assessment and Measurement

During field data collection in NFI5 several variables relevant to stem quality were assessed for all trees within the field plot. The most relevant is the tree shape (good form, forked, thick branches, curved base, curved stem, leaning tree, dried top, broken top, shrubby tree, tree lying on the floor). Just the living trees above the dbh threshold are classified for shape.

In addition, several other variables assessed on individual trees may contribute to the evaluation of stem quality such as the tree status (alive, burned, dead, failure in a plantation, stump, burned stump), the height of the living crown base, if the tree is a border tree in the stand, and some other stand and site specific variables like management type and elevation above sea level.

34.3.2.3 Estimation and Models

In order to obtain volume estimates by assortments different systems of equations are used for the maritime pine and eucalyptus (AFN 2010). The system of equations for each species includes a volume equation (total volume over bark), a taper equation (upper-diameters over bark) and a volume ratio equation (volume under bark to an upper diameter, excluding stump) that are applied to each individual tree within the plot to estimate the respective merchantable assortments. Stem quality information was not considered in the computation of volume by assortments presented in NFI5.

34.3.3 Assessment of Change

34.3.3.1 Assessment and Measurement

During the photointerpretation phase of the NFI6 the aerial photographs of the two previous NFIs (1995 and 2005) were re-analysed and the photo-plots corresponding

to the same grid of 500 × 500 m were photo-interpreted using a software that allows the simultaneous observation of each plot over time by the same photo-interpreter and applying the same rules. This methodology allowed a very good estimation of land use/land cover changes that led to the correction of the estimations of forest areas that had been published in the previous NFIs. As previously mentioned, changes of volumes and biomass have not been directly calculated from the NFI data as the field plots are not permanent.

34.3.3.2 Estimation of Increment

Increment has not been computed directly from NFI data. Increment may be estimated for the three most important tree species using the regional simulators available for the country (Barreiro and Tomé 2011, 2012; Tomé et al. 2015). When reporting for the Kyoto protocol, Portugal uses a different method (see Sect. 34.3.1.2).

34.3.3.3 Estimation of Drain

In Portugal, drain is estimated from different data sources, namely production statistics provided by industrial associations and reported production data in national surveys. Wood imports data are considered for data calibration for national production. Coefficients are then applied to production data for estimating removal, while natural losses are estimated from NFI data on tree mortality.

The Portuguese National Report on Greenhouse Gases (Pereira et al. 2014) uses a slightly different method based on several assumptions. It is not possible to classify by harvesting type, but the majority of harvested wood comes from clear-cuts. Major wildfire events contribute to a high amount of wood harvested in salvage logging. In maritime pine stands, large harvest volumes have also originated from sanitary measures such as a consequence of the pine nematode.

34.3.4 Other Wooded Land and Trees Outside Forests

34.3.4.1 Assessment and Measurement

The sampling grid of NFI5 covers all land-use classes of the Portuguese territory. As previously mentioned the plots coinciding with forest area are measured according to a 2 × 2 km grid and the ones coinciding with shrub-lands according to a 4 × 4 km grid. Shrubland has a broad intersection with other wooded land definition of FAO (2004). Measurements on Trees Outside Forest have been restricted to those occurring in the shrubland plots.

34.3.4.2 Estimation

Shrubland and Other Wooded Land areas were both assessed in NFI5 (see Table 34.2). These strata together correspond to the Other Wooded Land according to the FAO definition (FAO 2015). Information retrieved from photointerpretation analysis also enabled the estimation of the non-forest area with the presence of forest trees (Trees Outside the Forest).

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