Chapter 26
Italy

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26.1 The Italian National Forest Inventory

26.1.1 History and Objectives

The first Italian National Forest Inventory (NFI) was carried out between 1983 and 1986, with the results referenced to the year 1985 (MAF-ISAFA 1988). That inventory adopted a single-phase sampling design and the ground survey was carried out within plots systematically distributed on a 3 × 3 km grid across the country. By the end of the 1990s the information provided by the first NFI appeared to be dated and also insufficient to meet the information requirements resulting from the international processes that commenced in the intervening years. Following a feasibility study carried out in 1999 (ISAFA 1999), a Ministerial order founded the Italian National Forest Inventory as a permanent tool for forest monitoring. At the same time, the second Italian inventory was launched in 2001. It was carried out between 2002 and 2006 (reference year 2005), with a supplementary survey on soil carbon in the years 2008 and 2009. The second Italian inventory started due to the pressing need of statistics on forest carbon pools; for this reason it was named "National Inventory of Forests and forest Carbon pools" with the acronym "INFC". Starting with the second inventory, the results of the NFI are considered to be the official statistics, but are not used for timber/wood production statistics. Previously the official forest statistics were provided by the Italian Institute for Statistics (ISTAT) and were based on information collected in the 1950s and annually

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updated through questionnaires completed by the National Forest Service (NFS) officers. Another important innovation of the second NFI has been that to provide reliable data at the regional level, since regional or sub-regional forest inventories had been carried out by only half of the Italian regions between 1985 and 2000 (Gasparini et al. 2010a; Tosi and Monteccone 2004). The planning of the third national forest inventory started in the autumn of 2012 and its first phase was carried out in 2013; its reference year is likely to be the year 2015. The aim of this inventory is to make available up-to-date statistics needed for forest policy at national and regional level and to provide the Italian authorities with the data required by international agreements. NFI data are used for national reporting for the Kyoto protocol and the UNFCCC, and for international enquiries such as the FAO Forest Resources Assessments and the Pan-European reporting. The NFI also supports public administrations carrying out regional level inventories and research institutions by providing data and/or original estimates. The three Italian inventories are also known as IFNI85, INFC2005 and INFC2015. They have been carried out by the NFS, that is responsible for the project funding, logistic and surveys. The Forest Monitoring and Management Research Unit within the Agricultural Research Council (CRA-MPF) is the scientific coordinator and is responsible for the protocols, the field staff training, data control, data processing and the publication of results.

26.1.2   Sampling Methods and Periodicity

The Italian NFI adopts a three-phase sampling design for stratification (Fattorini et al. 2006) (Fig. 26.1). The first phase is carried out by photo-interpretation of about 300,000 sampling points randomly selected (one per each square km cell of the sampling grid covering the country) using aerial ortho-photographs (black and white for INFC2005, colour and infrared for INFC2015). The photo-interpretation
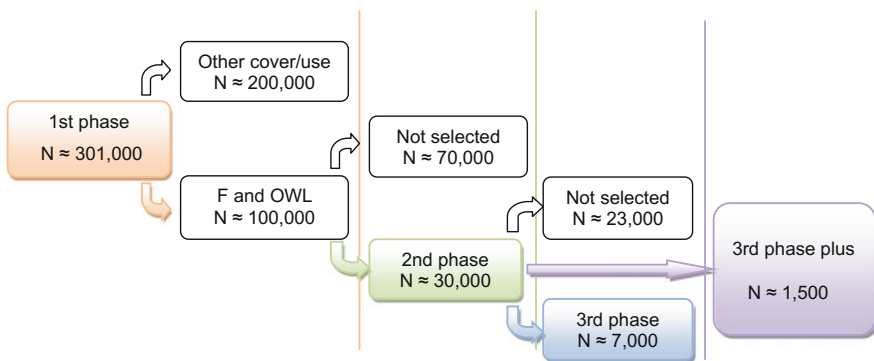

Fig. 26.1 Number of sampling points and flow diagram

is carried out by observing the land cover/land use of an area around each sampling point to derive a preliminary estimate of the extent of Forest and Other Wooded Land (OWL) at national and regional level and to define the second phase strata. The second phase is carried out in the field on a subsample of the first phase points randomly selected from forest land cover/use, stratified by Administrative Region (about 30,000 sampling points in INFC2005—one point every 349 ha of Forest and OWL). The main objective of the second phase is to refine the first phase classification, distinguishing Forest from OWL, and to identify third phase strata. Observations are carried out within circular plots of 2500 m^2, each centred on a NFI sample point. Each sample plot is classified according to a scheme consisting, among others, of 23 forest categories. The third phase is carried out on a subsample of the second phase sample plots, stratified by Region and forest category (about 7000 in INFC2005—one point every 1276 ha of Forest) (Gasparini et al. 2010a). The third phase aims primarily at estimating quantitative parameters (growing stock, annual increment, deadwood biomass, regeneration, others). Fieldwork principally concerns the assessment of trees and deadwood within two circular concentric plots (radii 13 and 4 m); regeneration and shrubs were measured in two small satellite plots (radius 2 m). In INFC2005, an additional survey (third phase plus) was carried out in 2008 and 2009 on about 1500 plots especially addressed to survey and sample litter and soil for carbon estimation (Gasparini 2011; Gasparini and Di Cosmo 2014). Third phase plus plots selection followed same criteria as for the third phase (random selection of second phase sample plots, stratified by Region and forest category). Observations and measurements on vegetation were carried out following the third phase protocol. In addition, litter and soil were sampled within three squared areas/pits (Gasparini et al. 2010b; Gasparini and Rizzo 2013) per NFI sample plot. Samples of deadwood, regeneration and shrubs were collected for laboratory analysis. Basic density values were derived for deadwood at different decay stage, while for undergrowth vegetation the dry and fresh weights were calculated (Di Cosmo et al. 2013).

The first phase of the new cycle (INFC2015) was completed during 2013–2014 and the reference year of its final results from the field surveys is planned to be 2015, with a cycle length of 10 years. The sampling design of the new cycle is unchanged, but some changes concern the distribution over time of the field surveys and the third phase sample size. A re-measurement of a large part of INFC2005 third phase plots is also planned, as their plot centre was permanently marked, even though estimates on changes will not rely on permanent plots, as no information about tree position was collected.

26.1.3   Data Collection

The data recorded for each sample point varies from phase to phase. In the first phase, each point is classified according to broad land use/cover categories consistent, at the highest level, with the Corine Land Cover system (European

Commission 1993). A subsample of the points classified as Forest or Other Wooded Land according to the FAO definition is selected for field visit during the second phase, with the aim to survey qualitative variables and definitively classify the vegetation in accordance with a system of forest categories and sub-categories. Quantitative measurements are carried out during the third phase, although some qualitative observations are also recorded. The third phase plus protocol on vegetation survey is similar to the third phase one, but further investigations and measurements are carried out on deadwood and woody understory vegetation of which samples are collected for laboratory analysis.

The most important qualitative information recorded, by broad category, is related to:

- administrative data—ownership, restriction for forestry use, planning, wood availability
- site features—land use/cover, elevation, exposure, slope, accessibility
- vegetation characteristics—inventory category, forest category and sub-category, conifer/broadleaves mixture
- stand features: crown cover, development class, age class, texture, origin, health status (defoliation, disease, damage, etc.), silvicultural system, harvest method, extraction method.

Quantitative data include:

- for all trees—species, diameter at breast height (dbh), vitality and integrity, decay class (only for dead trees)
- for sample trees—total height, height of the base of the crown, diameter increment
- for regeneration and shrubs—number of individual plants by species and dimensional class, origin, damages, individual mean weight (fresh and dry after laboratory treatment)
- for deadwood—standing dead trees, diameter at breast height, total height and decay class
- for deadwood—coarse woody debris, the two end diameters, the distance between the two (debris length) and decay class
- for stumps, diameter at cut section, height and decay class;
- for fine woody debris, weight per area unit (fresh and dry weight after laboratory treatment).

The NFI sample plot configuration is illustrated in Fig. 26.2. With reference to wood supply, concentric circular plots are used for callipering (radius 4 m: dbh ≥ 4.5 cm; radius 13 m: dbh ≥ 9.5 cm) and height/increment sample trees selection; 2 m circular plots are used for regeneration and shrub measurements. Stumps of removed trees (diameter ≥9.5 cm) are measured within the 13 m plot. Squared areas (S1–3) are used for litter and soil measurement and collection.

Fig. 26.2 NFI sample plot configuration
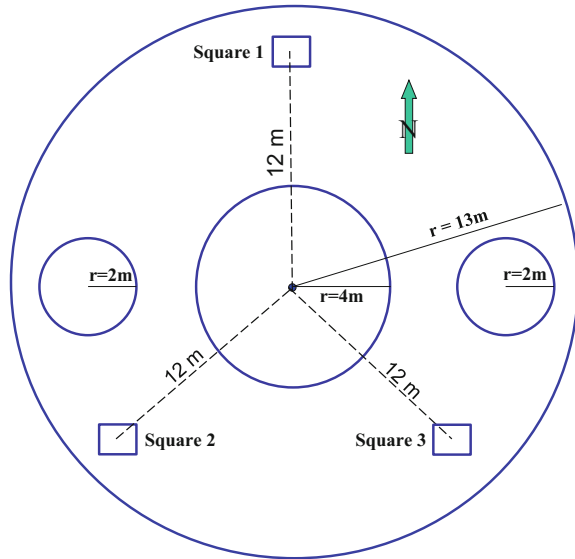
26.1.4 Data Processing, Reporting and Use of Results

Sample tree data are used to develop species-specific models for predicting total tree height from tree dbh and plot tree dominant height, in such a way to predict the height of any callipered tree (Tabacchi and Di Cosmo 2011). The stem volume (including large branches) of any tree in the plot is estimated by species-specific functions that use dbh and total tree height as independent variables and above-ground tree biomass is estimated by species-specific functions on the basis of the same two independent variables (Tabacchi et al. 2011a). The volume and biomass of all trees in the plot are summed up to get the value per hectare of the plot. Diameter increment measured for the sample trees is used to estimate the mean percent increment for the plot, which is weighed by tree size. By using the mean percent increment and tree dbh, the current annual increment of any tree in the plot is then estimated and finally current annual volume increment of the plot is obtained.

The total forest area and its distribution by forest type are calculated by a two-phase estimation process from the land use/land cover data of the first inventory phase (photo-interpretation) and the field classified forest categories and sub-categories of the second phase. The weight of each land use/land cover stratum in the Regions of Italy (*Wij*) is equal to the proportion "number of first phase sample units of the stratum divided by total number of sample units". The area of each inventory stratum *k* (forest, forest category or sub-category) is calculated by multiplying the total area of the sampling grid by the sum of the proportions of second phase sample units assigned to the inventory stratum (*Wijk*), for each land use/land

cover stratum, multiplied by *Wij*. The sums of estimated areas of inventory strata at regional and national level are then calibrated with the known values of the regional/national total land area provided by ISTAT for the year 2002.

The total value for a quantitative variable (volume, biomass, increment) for each inventory stratum is derived from the sum of sample averages of the Horvitz-Thompson estimates (Horvitz and Thompson 1952) of the total of the variable multiplied by the stratum weight (combined weight, *Wij* by *Wijk*). Horvitz-Thompson (1952) estimates of the total of the variable in the sampling units of the stratum are equal to the total values of the variable measured in a plot of a prefixed area multiplied by the ratio between the area of the cell containing the sample point (1 km^2) and the plot area (Fattorini et al. 2006).

The results of the Italian NFI are made available as soon as they are obtained, by publishing on the official webpage (www.infc.it). After each cycle a book is published to make methods and results available in the most comprehensive and methodical way. The Italian NFI supports international reporting in many ways. Firstly, by providing statistics on forests and related variables that are directly usable for the reports; secondly, by computing ad hoc estimates based on NFI data; thirdly by the participation of NFI experts in workshops or technical meetings; lastly by continuous efforts to harmonise national definitions and methodologies for producing estimates eligible for international reporting requirements. The main reporting processes in which the Italian NFI is involved are: the Forest Resources Assessments of the Food and Agriculture Organization (FAO-FRA), the reporting on Land Use, Land-Use Change and Forestry (LULUCF) under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, the monitoring of forest management sustainability for the Ministerial Conference on the Protection of Forest in Europe (MCPFE) and more recently for FOREST EUROPE.

26.2 Land Use and Forest Resources

26.2.1 Classification of Land and Forests

26.2.1.1 General Land Classification

The classification system adopted by the Italian NFI was defined under the requirement, stated in the NFI Ministerial order, to be consistent with the definitions agreed at the international level and the ones used by ISTAT. At the most general level (first order classification), the total country area is classified accordingly with the five CORINE Land Cover classes (European Commission 1993). The five classes are subdivided into eight second order land use/cover classes; only the most relevant for forest statistics among these are further subdivided (Table 26.1).

Table 26.1   Italian NFI classification system of land use/land cover

First order classification	Second order classification	Third order classification
Artificial surfaces	Urban parks	
	Other artificial surfaces	
Agricultural areas	Timber/wood plantations	
	Fruit plantations	
	Other agricultural areas	
Forests and semi-natural areas	Woodland	Tall trees forest
		Temporarily unstocked areas
		Other wooded land
	Grassland, pastures, uncultivated land	
	Open areas with little or no vegetation	
Wetlands		
Water bodies		

For forest, the FAO definition, as adopted in FRA2000 (UN-ECE/FAO 1997) is used; forest is made by tall trees forests, including young stands, temporarily unstocked areas and timber/wood plantations.

26.2.1.2   Forest Classification

The classification of forest (Table 26.2) is based on a system of 17 forest categories for tall trees forests, defined on the basis of the species prevalent in terms of crown cover, and three forest categories for timber/wood plantations (poplar plantations, other broadleaves plantations and conifer plantations). Forest categories are one of the stratification criteria for selecting the third phase sample (the other criterion being the Administrative Region). All the NFI statistics are produced with reference to the inventory macro-categories (Forest, OWL), the inventory categories (for the forest: tall trees forests, timber/wood plantations, temporarily unstocked areas) and the forest categories detailed in Table 26.2, either for qualitative attributes or quantitative ones, although estimates for some variables are further disaggregated (e.g. number of trees, basal area, volume, biomass and annual increment by species, by diameter class, by stand age). In Table 26.2, the area of the OWL inventory categories is given for the purpose of comparison. Forest categories are named after the prevailing tree species, in terms of crown cover. NFI statistics are available at http://www.infc.it.

Table 26.2 Area, growing stock and annual increment of the Italian Forest by forest category, and area of the inventory categories of the Other Wooded Land

Inventory category of forest	Forest categories	Area (ha)	Volume (m³)	Annual increment (m³)
Tall trees forests	*Larix decidua* and *Pinus cembra*	382,372	76,930,988	1,282,925
	Picea excelsa	586,082	218,166,422	4,567,710
	Abies alba	68,460	29,244,196	565,119
	Pinus sylvestris and *Pinus uncinata*	151,671	29,011,580	529,251
	Black pines group (*Pinus nigra* Arn., *Pinus laricio* Poiret)	236,467	53,280,460	1,404,011
	Mediterranean pines (*Pinis pinea* L., *Pinus pinaster* Ait., *Pinus halepensis* Mill.)	226,101	30,204,769	833,255
	Other coniferous forests	63,407	12,496,202	404,893
	Fagus sylvatica	1,035,103	240,009,507	5,597,810
	Temperate oak spp. (*Quercus pubescens* Willd., *Quercus petraea* Liebl., *Quercus robur* L.,)	1,084,247	77,405,681	2,206,439
	Mediterranean oak spp. (*Quercus cerris* L., *Quercus frainetto* Ten., *Quercus trojana* Webb., *Quercus macrolepis* Kotschy.)	1,010,986	103,797,336	3,233,075
	Castanea sativa	788,408	139,697,903	4,941,237
	Ostrya carpinifolia and *Carpinus betulus*	852,202	68,949,448	2,452,274
	Hygrophilous forests	229,054	24,382,385	960,264
	Other deciduous broadleaved forests	994,777	94,003,164	4,006,403
	Quercus ilex	620,318	45,598,302	1,453,949
	Quercus suber	168,602	8,444,671	220,298
	Other deciduous broadleaved forests	84,712	4,476,479	226,448
Timber/ wood plantations	Poplar plantations	66,269	7,518,275	621,688
	Other broadleaved plantations	40,985	1,976,387	196,488
	Coniferous plantations	14,998	2,751,832	121,672
Temporarily unstocked areas	Temporarily unstocked areas	53,981	1,070,512	47,083
	Total forest	8,759,200	1,269,416,499	35,872,293
Inventory category of other wooded land				
Short trees forest	–	124,229	–	–
Sparse forest	–	146,415	–	–
Scrubland	–	468,678	–	–
Shrubs	–	990,916	–	–
Inaccessible areas	–	398,095	–	–
	Total other wooded land	1,708,333	–	–

26.2.1.3   Classification by Ownership Categories

Overall, two third of forests are private in Italy (Table 26.3) but a larger part (87.1 %) of plantations are privately owned. Among the private ownership types, individuals hold the highest percentage (79.1 %), whereas most of the public ownership belongs to Provinces or Municipalities (65.8 %).

26.2.1.4   Legal and Other Restrictions for Wood Use

Although differences are found among the Administrative Regions and/or other public bodies (such as, for example the National Parks), permits are generally required for cutting trees. For example, 87 % of forests are on areas with restrictions for hydrogeological protection. Cuttings in these forests have to be explicitly authorised by the regional forest authority, as stated by the national law. In practical terms, this takes the form of an approval process where a harvesting plan prepared by a professional forester is submitted for approval. This plan describes what is proposed to be cut, quantities, tools used for extracting, etc.

   Apart from national laws like the one described above, a number of legal restrictions may affect availability of wood supply such those listed below. However it is important to notice that if a forest area is within one of the following categories, it does not indicate, as a direct consequence, that cuttings are not allowed:

Table 26.3 Forest ownership of forests in Italy

Ownership	Type	Area (ha)	Area (%)
Private forest	Individual	4,583,893	
	Corporate	358,705	
	Other private entities	258,792	
	Unknown	596,325	
	Total private	5,797,715	66.2
Public forest	State or Region	695,153	
	Province or municipality	1,920,967	
	Other public entities	244,231	
	Unknown/not recorded	71,336	
	Total public[a]	2,931,688	33.5
Unknown		29,798	0.3
Total		8,759,200	100

[a]The sum of the public forest types differs from the overall total public by 1 ha. This is due to computational approximations (totals are estimated independently by the NFI and not as a sum of types)

National Parks, Regional Parks, Natural Reserves, Natura 2000 sites, Sites of Community Importance (SCI), Special Protection Areas (SPA) and others may include areas where cutting is definitively forbidden (strict nature reserve, that covers 93,127 ha in National Parks) but generally involves "only" stricter/different criteria for utilisation, for protection purposes. Forest areas marked by presence of special restrictions (military, or proximity to airports, roads, railways, electrical lines, etc.) is on the whole restricted (only 27,803 ha).

The characteristics that make a forest available for wood supply depend on many variables that involve legal restrictions, accessibility (e.g. slope, roading and harvesting technology) and others more explicitly related to the economical viability for forest operations. Field crews are asked to assign each plot to available/not available for wood supply. This direct classification of plots was adopted because comparable stands may be different in availability due to regional/local features, for example wood/timber market, forestry traditions, tree cutting due to family forest rights, etc.

26.2.1.5 Further Classification of Forests

Further classification of forest areas is based on forest sub-categories, broadleaves/conifers mixture, crown cover percentage, texture, vertical structure, protection status. Concerning timber/wood production, forests are classified by silvicultural system, development stage, age class and availability for wood supply.

26.2.2 Classification of Other Wooded Land and Trees Outside Forests

26.2.2.1 Other Wooded Land Classification

Other wooded land (OWL) is defined as in FRA2000 (UN-ECE/FAO 1997) and further classified accordingly into four inventory categories:

- short tree forest (formations with cover greater than 10 % of tree species with potential height in situ between 2 and 5 m)
- sparse forest (formations with cover between 5 % and 10 % of tree species with potential height in situ of at least 5 m)
- scrubland (formations with cover greater than 10 % of trees with potential height in situ less than 2 m)
- shrubs (formations with cover greater than 10 % of shrub species and tree crown cover less than 5 %).

By convention also inaccessible areas (plots neither reachable nor visible from a distance for secure vegetation classification) are assigned to OWL.

26.2.2.2   Trees Outside Forests

Trees outside forest (TOF) are not assessed in the NFI. Nevertheless, on the basis of the first phase photo-interpretation data, parallel investigations have been carried out and a number of studies completed (e.g. Paletto et al. 2006; Pignatti et al. 2011; De Natale et al. 2011; De Foresta et al. 2013). The national definition for TOF used in these studies includes "linear formations" of forest trees (at least three trees), 3–20 m width, and "small woods" of forest trees with a minimum tree crown cover of 10 %, larger than 20 m but spanning less than 0.5 ha. The mentioned studies aimed primarily to assess consistency of TOF, frequency by the two TOF components by Province as well as relations with agricultural systems and forests (e.g. distance from the nearest forest).

26.2.3   Wood Resources and Their Use

26.2.3.1   Standing Stock, Increment and Drain

Trees species composition in the Italian forests, in terms of number of trees (dbh ≥ 4.5 cm), basal area, volume, current annual increment and biomass are presented in Table 26.4. The species listed provide all together the 80 % of the timber/wood volume and the remaining 20 % is given by about thirty other species (Pignatti and De Natale 2011).

Species in Table 26.4 have been ordered by decreasing volume. All forest species in Italy have commercial value since they mainly supply fuelwood and timber to a lesser extent. For this reason, the species data in Table 26.4 is not indicative of the total potential available for wood supply. Forest area is more useful to assess availability. The proportion between the use for fuelwood and for timber is also due to inherent characteristics of the species and some of them are used exclusively or predominantly for fuelwood. Among the most important and widespread broadleaves, beech and chestnut are found either in high forests or in coppices and produce both fuelwood and timber.

The distribution of forest area by silvicultural system and development stage provides a general overview on potential wood/timber supply. Table 26.5 details the distribution of tall trees forests, whose area covers the 98 % of the total forest area in the country.

Plantations are generally available for wood/timber supply but cover only a small proportion of the total forest area (1.4 %—see Table 26.2). Quantitative NFI surveys are not carried out in OWL or TOF. For this reason, availability of wood/timber from them is not assessed and still not known for the whole country.

Increment and drain are assessed in all the third phase NFI plots, regardless of any criteria related to management, wood availability or species. Increment is calculated on the basis of the mean percent annual increment of sample plots, and statistics are produced by forest categories (Table 26.2) and by species

Table 26.4 The main thirteen tree species in the Italian forests, in terms of growing stock of volume (http://www.infc.it)

Species	Number of trees (1000)	Basal area (1000 m²)	Volume (1000 m³)	Annual increment (1000 m³)	Biomass (1000 Mg)
Fagus sylvatica	1,402,336	26,996	218,746	5108	174,059
Picea excelsa	459,099	19,237	202,582	4228	101,680
Castanea sativa	954,212	19,799	130,899	4667	82,279
Quercus cerris[a]	915,137	13,786	93,965	2906	76,354
Larix decidua	142,054	9158	81,693	1438	43,835
Quercus pubescens Willd.[a]	980,276	13,202	72,228	2162	62,298
Ostrya carpinifolia Scop.[a]	1,315,310	8656	42,840	1496	39,021
Quercus ilex[a]	815,437	7117	35,174	1080	35,729
Abies alba	74,621	3312	34,344	705	17,572
Pinus nigra	116,730	4071	30,456	817	18,960
Pinus silvestris	111,837	4069	30,129	584	16,801
Pinus laricio	63,869	3407	24,693	698	10,318
Robinia pseudacacia L.[a]	295,187	3130	20,930	1004	17,206
Other species	4,303,527	42,494	250,736	8980	178,331
Total	11,949,631	178,434	1,269,416	35,872	874,443

[a]Species used exclusively or predominantly for fuelwood

Table 26.5 Tall trees forest by silvicultural system and development stage (http://www.infc.it)

Silvicultural system	Development stage	Area (ha)
Coppices	Young stands	361,615
	Adult stands	2,045,382
	Mature stands	1,216,183
	In regeneration stands	18,124
	Uneven-aged sprout coppice (coppice selection)	21,471
	Development stage not classified	369
	Total	3,663,143
Even-aged high forest and singled coppice	Seedling	12,478
	Sapling	27,615
	Pole	95,934
	Mature and over-mature	530,039
	Regenerating forest (clear cut)	839,177
	Development stage not classified	3412
	Even-aged high forest and singled coppice	369
	Total	1,509,023
Uneven-aged and irregular high forest	Not relevant	1,648,943
Special or not canonical silvicultural system	Not relevant	1,761,860
Tall trees forest	Total	8,582,968

(Table 26.4). Drain is estimated as the volume of trees removed in the twelve months before the survey, from the stump diameter (Table 26.6).

Stand origin is natural or semi-natural in the 85 % of forest area. Once the plantations are excluded, forests are almost exclusively established with natural regeneration by means of coppice shoots (about 43 % of the tall trees forest area is covered by coppice forests) and seeds from seed bearing trees.

Generally stands are simply cut when they are mature (70 % of forest area under silviculture) and the 23 % of them is treated also with tending, thinning during the rotation and other practices. The remaining 7 % is managed more intensively (with practices typical of plantations or stands cultivated for non-wood forest products).

Table 26.6 Drain (volume of stem and large branches of trees cut in one year) from the Italian forests

	Tall tree forests	Plantations	Temporarily unstocked areas	Forest
Total (m^3)	13,362,266	409,213	25,384	13,796,864
per hectare (m^3)	1.6	3.4	0.5	1.6

26.3 Assessment of Wood Resources

26.3.1 Forest Available for Wood Supply

26.3.1.1 Assessment of Restrictions

A strict national definition for forest available for wood supply (FAWS) does not exist, and the UNECE-FAO reference definition is used to classify the plot as forest available/not available for wood supply. Field staff are asked to make a synthesis of all useful information/evaluations (restrictions due to laws, orography, physiography, roads, stand characteristics, local uses, others) that suggest whether or not cuttings are feasible/realistic. The evaluation is also based on the economic value of wood and timber.

Whether or not the NFI plot is contained in a protected area (whichever the type) is generally known before going to the field, from accessible national GIS database. Maps are also available on other types of restriction/protection status, such as the hydrogeological protection areas. As the survey is conducted by NFS foresters working in their own region, they are generally aware of local additional restrictions and are also encouraged to ask for the cooperation of the forest office based in the specific area where the NFI plot is located.

Variables on legacy status and related to availability for wood supply are:

- general restrictions for nature conservation

    - inclusion or not in National Parks (by degree of protection in case of plots in National Parks)
    - state natural reserves, regional parks, regional natural reserves, other protected areas (classified according to the national law)
    - NATURA 2000 sites (Special Areas of Conservation—SACs—and Special Protection areas—SPAs)
    - Ramsar List of Wetlands of International Importance

- special restrictions

    - military
    - proximity to airports, roads, railways
    - electrical lines.

Other kinds of variables related to FAWS are recorded in each plot, including: terrain gradient; roads (distance and difference in level between plot and nearest road); elevation; ground roughness; accessibility.

Based on NFI field staff assessment of FAWS, a large majority (88.4 %) of the forest area (7,741,176 ha) is available for wood supply. The direct judgment of availability assessed in the field represents the most reliable synthesis of the influence of the various factors (site related, legal, and economic) affecting wood availability in the specific context of the Administrative Regions.

26.3.2 Wood Quality

26.3.2.1 Stem Quality and Assortments

The Italian NFI does not provide estimates on stem quality and assortments. Official statistics on timber/wood production in Italy are not provided by the NFI, and are not based on NFI data on drain.

Italy is traditionally a timber/wood importing country. According to FAO (2013 data), half of the production of timber and wood in the decade 2002–2012 consisted of woodfuel and only about 30 % of the production was made of assortments related to stem quality (Fig. 26.3). Statistics refer to round wood, wood chips and particles, wood residues, sawn wood. Distribution of forest species usable for timber production varies consistently along the country, as well as forestry traditions linked to their use, markets and presence of local industries. In spite of expertise and time required for the assessment of stem quality during the NFI survey, the gain of such an evaluation is thought worthless, because of the many factors affecting timber production.

26.3.3 Assessment of Change

26.3.3.1 Assessments and Measurements

The stem and large branch volume increment (upper stem diameter limit for branches and top—5 cm) of living trees is assessed in the third phase plots. Variables related to the increment assessment are:
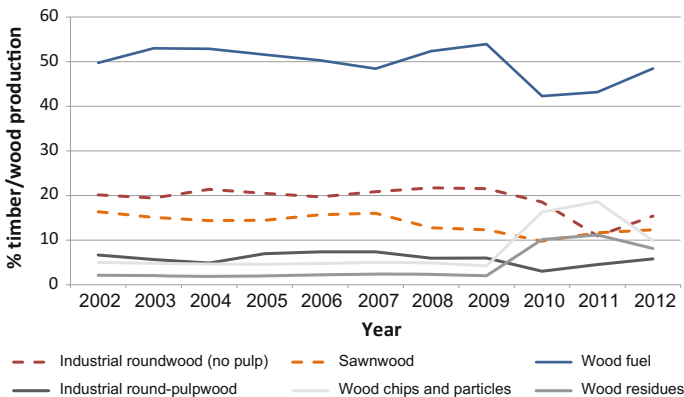

Fig. 26.3 Percentage of timber/wood production by item in the decade 2002–2012 in Italy (data from FAO 2013)

1. diameter increment—one specimen core is taken with a borer from the sample trees in the plot and annual increment is measured from bark to pith.
2. height increment—the height of the cored trees at the inventory year and that at the former time (nominally one year before) is estimated by tree height prediction models based on dbh and plot dominant height.

26.3.3.2   Estimation of Increment

To estimate the annual increment, cores are taken from sample trees. The sample trees are selected among those callipered in the NFI plot and free from visible faults, using a protocol based on both random and representative criteria. The five trees nearest to the plot centre, the three largest ones and two of the rarest by species or size in the plot are selected as sample trees. As the trees in the last two categories may be also among the nearest to the plot centre, the total number of sample trees per plot ranges between five and ten.

At sample tree level, the data recorded for volume increment estimation are: species, diameter over bark and total height. In order to estimate the current diameter increment, one core per sample tree is taken with a Pressler increment borer at 1.30 m above ground level. The core is taken along with the plot centre direction, in order to avoid systematic annual rings eccentricity due to site features, such as slope, prevailing winds and others. The thickness of the outermost 5 rings (excluding the current year ring) of each core is averaged to get the mean annual increment (of the radius, at this stage). The former dbh of the tree (nominally one year before the callipering) is computed as the current dbh minus the mean annual dbh increment, assuming that bark thickness does not change during the five years period.

Sample trees heights, i.e. the total tree height of the current year and tree height one year before the inventory year, needed for increment estimation are calculated using the following model, developed using 45,332 sample tree diameter-height data collected during the NFI survey:

$$\hat{h}_{ij} = (a_1 + a_2 H_{dom})[1 - \exp((a_3 + a_4 H_{dom})d_{ij})]^{(a_5 + a_6 H_{dom})} \tag{26.1}$$

where h_{ij} is the height of the generic tree i in the generic sample plot j
d_{ij} is the *dbh* of tree i in plot j
H_{dom} is the dominant height of the plot j
a_x are species dependent coefficients (55 height-predicting equations).

The volume of a tree is estimated by species specific prediction equations (Tabacchi et al. 2011a, b) of the following type:

$$\hat{y}_1 = b_1 + b_2 d_i^2 h_i + b_3 d_i \tag{26.2}$$

where y_i is the volume of the generic tree i

d_i is the *dbh* of tree i

h_i is the total height of tree i

b_x are species specific regression coefficients (26 volume-prediction equations).

The percent volume increment of a generic sample tree z in the plot j (pv_{zj}) is obtained by the following formula:

$$pv_{zj} = 100\left[\left(2\Delta d_{zj}/d_{zj}'\right) + \left(\Delta h_{zj}/h_{zj}'\right)\right] \tag{26.3}$$

where Δd_{zj} is the annual *dbh* increment of the sample tree z in the plot j, known from the ring width measurements.

d'_{zj} is the *dbh* of the tree z in the plot j one year before the inventory year, known from callipering and tree ring width)

Δh_{zj} is the annual height increment of the generic sample tree z in the plot j, known from model (26.1)

h'_{zj} is the height of the tree z in the plot j one year before the inventory year, known from model (26.1).

The percent volume increment (pv) of all the z trees sampled in a plot j are used to calculate the mean weighed percent increment of the plot j (pv_j), by the following formula:

$$pv_j = \sum_{z=1}^{m} \left(Vol_{zj} \times pv_{zj}\right) \Big/ \sum_{z=1}^{m} Vol_{zj} \tag{26.4}$$

where

m is the number of the sample trees in the plot j

pv_{zj} is the percent volume increment of the generic sample tree z in the plot j

Vol_{zj} is the volume of the generic sample tree z in the plot j, known from model (26.2).

The current annual increment of the generic tree i callipered in the NFI sample plot j (Δv_{ij}) is then obtained by the following:

$$\Delta V_{ij} = Vol_{ij} \times pv_j \tag{26.5}$$

where

Vol_{ij} is the volume of tree i in plot j, known from model (26.2)

pv_j is the mean weighed percent volume increment for the trees in the plot j, known from (26.4).

Finally, the annual volume increment of the growing stock in plot j as a whole (ΔV_j) is obtained by the sum of the annual volume increment of each tree in the plot:

$$\Delta V_j = \sum_{i=1}^{n} \Delta v_{ij} \times f_{ij} \qquad (26.6)$$

where

n is the number of trees callipered in the plot j (dbh $\geq$ 4.5 cm)
f_{ij} is the expansion factor of the tree (two factors, depending on tree dbh or plot radius to obtain the annual increment per area unit).

The increment of trees that were cut or of those trees that have died is not estimated. The increment estimated by the Italian NFI is that of living trees at a certain point in time. Such a procedure assumes that the current stand conditions are reasonably like those of the very recent past (from which the rings width information are taken, on average) as well as of the near future, for which estimation is considered valid.

26.3.3.3   Estimation of Cuttings, Removals and Mortality

Cuttings are estimated by predicting the volume (volume of stem and large branches) and biomass (total aboveground biomass except stump) of trees felled in the 12 months preceding the survey and whose stump diameter is equal to or greater than 9.5 cm. Stumps are surveyed in the 13 m radius plots, recording the species, the diameter at the cut section (two cross diameters) and the height (two heights, the minimum and the maximum height). Weather the felling was carried out in the last year before the field inventory survey or earlier is assessed visually (observing the condition of wood at the cut section, the decay status of stumps, etc.), but may also be reported from the local forest service station that oversaw the felling operation. The procedures for estimating the volume and the biomass of each felled tree are similar with those adopted for intact living trees, once the dbh of removed trees has been predicted. This is predicted using the two following equations, one for conifers (26.7) and one for broad-leaved species (26.8) (MAF-ISAFA 1988):

$$dbh = -2.42525 + 0.87427\, d_{stump} \qquad (26.7)$$

and

$$dbh = -1.43966 + 0.77839\, d_{stump} \qquad (26.8)$$

Based on the two equations, the minimum dbh considered for removed trees is 5.9 cm for the conifers and 6.0 cm for the broadleaved species. The height of each removed tree is estimated by the model (26.1).

Both the stem and large branch volume (upper diameter for branches and top—of 5 cm) and the total above ground tree biomass (stump, stem, tree top, large branches and small branches) are estimated by the species specific prediction model (26.2). The overall volume of extracted trees for the entire sample unit is obtained by summing up the volumes of all the trees removed.

The aim of the measurements and estimation procedures described is to assess the wood/timber removed in one year. No distinction is made between cuttings from living trees and the removal of trees which died naturally. For instance, in case of trees downed from a storm (broken section <1.30 m) and afterwards extracted for wood/timber use, their volume is estimated as part of the removals without any further specification between downed from storm or from routine felling.

Despite the accurate information recorded in the field, statistics on removals are published only as total values for the inventory categories (tall trees forest, plantations, temporarily un-stocked areas) and Administrative Regions. In fact, as stumps from recent cuttings are observed in quite a limited number of plots, estimates by any further detail (forest category, tree species, etc.) are affected by considerably high standard errors.

26.3.3.4   Estimation of Forest Area Change

Changes in forest area are derived from repeated NFI assessments. More precisely, the first two phases of any NFI cycle provide an updated forest area estimate comparable with the former one. Such an approach became possible starting with INFC2005, when the Italian NFI was founded as a permanent tool for forest consistency monitoring. The first phase photo-interpretation of the third Italian NFI (INFC2015) and the forthcoming second phase will allow to assess the changes in the decade 2005–2015. Forest area changes from the time of the first Italian NFI (1985) to 2005 have been estimated by reclassifying the IFNI85 categories into the INFC ones in order to allow consistent comparisons. This approach was used for the FAO-FRA reporting (Mariano et al. 2010) and also for the UNFCCC and Kyoto Protocol reporting.

26.3.4   Other Wooded Land and Trees Outside Forests

26.3.4.1   Assessment and Measurement of OWL

The area of other wooded land is assessed during the first two inventory phases and is estimated to be 1,708,333 ha or 5.7 % of the country area. A number of qualitative second phase variables are surveyed, and the related estimates are published in the web site. Among those variables, many are related to wood availability: coniferous, broadleaved and mixed area; variables on restrictions and protection status; accessibility; others. Availability for wood supply itself is also explicitly

assessed, as discussed for forests. However, quantitative measurements on trees are not carried out, since plots in OWLs are not surveyed in the third phase, so that OWL tree volume and biomass are unknown.

26.3.4.2   Assessment and Measurement of TOF

Trees outside of the forest area was first estimated after the photo-interpretation carried out in 2005, using a parallel study (TOF Inventory) that was also the basis of subsequent investigations. Data interpreted from NFI personnel on the 4785 points classified as TOF were checked for validation and additional information recorded (quantitative and qualitative attributes such as land/cover use, width, length, distance from forest, etc.). Each TOF-point was also assigned to the surrounding land use. The total area covered by TOF (woodlots and hedgerows) was estimated as a proportion of TOF sampling units on total NFI points. TOF area covers about 452,000 a (S.E. = 1.5 %) that is 1.5 % of the country area. Two thirds of TOF area is made by hedgerows and the remaining by woodlots. TOF are mainly present in agricultural areas (cropland 82 %, pastures 6 %); the remaining 12 % is found in urban and periurban areas (10 %) and in not cultivated/not managed lands (2 %) (De Natale et al. 2011).

Countrywide studies on the quantitative attributes related to TOF growing stock have not been carried out until present and national statistics on volume and/or biomass are not yet available. However, from a Regional field survey investigation (Regione Veneto, De Natale et al. 2011) it emerged that 66.8 % of TOF area is still managed and the wood is utilised (coppicing, pollarding, pruning), showing that TOF are potentially interesting for wood supply.

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