Chapter 1
Introduction

Claude Vidal, Ola Sallnäs, John Redmond, Iciar Alberdi, Susana Barreiro, Laura Hernández and Klemens Schadauer

1.1 History of Use and Assessment of Wood Resources

Wood resources have been an essential component of life for human beings over the millennia and remain critically important today. Beginning with the first human habitations and fire to more industrial energy needs, wood was always essential for mankind. Access to sufficient supplies of wood was a vital part of a countries competitive advantage. Uses included fuel, industry, housing, shipping and temporary applications such as supporting trenches in the First World War. Some purposes required wood with specific characteristics, notably in ship building, which demanded softwood for masts and hardwood for keels. Such specialised requirements stimulated transnational exchanges and exports between countries.

European forests are the result of centuries of human activities (Spiecker 2003). Forest resources have been overused over the course of history, particularly during times of emergency such as, to supply timber for military ships and energy for armies or displaced populations. During and immediately after both world wars,

C. Vidal (✉) · O. Sallnäs
European Commission, JRC-IES, Ispra, Italy
e-mail: claudevidal2@gmail.com

O. Sallnäs
e-mail: ola.sallnas@slu.se

C. Vidal
French Ministry of Agriculture, Agrofood and Forestry, Paris, France

O. Sallnäs
Southern Swedish Forest Research Centre, Uppsala, Sweden

J. Redmond
Department of Agriculture, Food and the Marine, Johnstown Castle Estate, Co. Wexford, Ireland
e-mail: johnj.redmond@agriculture.gov.ie

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European forests were systematically overcut and principles of sustainable yield disregarded. In a few extreme cases, war has helped forests by allowing ecosystems to recover free of human pressure. For example, in the Hundred Years' War between England and France in the fourteenth century, the destruction and subsequent abandonment of many villages had a positive effect on forests. Wars are rarely fought over timber, but in Cambodia for example insurgent groups prolonged their struggles in part to engage in illegal logging operations (Le Billon 2000; Global Witness 2003). However, in more recent decades, increasing social demands required a wider scope of forest management based on sustainable forest management (Spiecker 2003).

Overtime wood resource evaluation and availability became a growing political concern. The first local investigation to evaluate the wood resources in Europe goes back to the Middle-Ages when the nobility required an assessment of wood availability on their territory. At that time intensive use of forest resources led, firstly to wood shortages which, in turn, forced forest owners to establish forest planning particularly in the vicinity of cities and mines (Loetsch and Haller 1964; Gabler and Schadauer 2007; Tomppo et al. 2010). Loetsch and Haller (1964) summarised: "the characteristics of the methods of forest inventory in Central Europe during the nineteenth century are very accurate area information from terrestrial surveying and area-related information on relatively small stands as units of assessment. The results of the stand inventories are compiled for groups of stands and finally for the whole independent management unit…" Thus, the first inventories were often local with the aim of assessing the available timber resources for some specific use. But it became obvious that such inventories could not be easily used to compile national level forest information.

However, it was not until the early twentieth century, in the late 1910s and early 1920s, when due to importance of forest and wood resources for their economy, the European Nordic countries initiated the first sample-based National Forest

I. Alberdi · L. Hernández
National Institute for Agriculture Research, INIA-CIFOR, Madrid, Spain
e-mail: alberdi.iciar@inia.es

L. Hernández
e-mail: hernandez.laura@inia.es

S. Barreiro
Centro de Estudos Florestais, Instituto Superior de Agronomia,
Universidade de Lisboa, Lisboa, Portugal
e-mail: smb@isa.ulisboa.pt

K. Schadauer
Federal Research and Training Centre for Forests,
Natural Hazards and Landscape (BFW), Vienna, Austria
e-mail: klemens.schadauer@bfw.gv.at

Inventories (NFIs). However, such tools were not introduced in other European countries until after World War II (Tomppo et al. 2010). During the reconstruction phase that followed World War II, the political importance of forest and forest resources were then recognised by the implementation of a NFI in 1958 in France, in the 1960s in Austria, Spain, Portugal and Greece; and in the 1980s in Switzerland, Italy, Poland and the reunified Germany. Today, statistical sample-based inventories are conducted in almost all European countries not only to investigate forest resources and elaborate National Strategies but also to answer international information requirements which are relevant for political decision making.

1.2 International Requirements for Information on Wood Resources

The main international requirements for forest information are the Food and Agriculture Organization of the United Nations (FAO) Forest Resources Assessment (FRA), and the obligations following from the commitments towards sustainable forest management and United Nations Framework Convention on Climate Change (UNFCCC). NFIs are the main data source for all these processes.

1.2.1 Food and Agriculture Organization of the United Nations (FAO)

The FAO Forest Resource Assessments has been monitoring the world's Forest at 5 to 10 year intervals since 1948: from FAO (1948) to FAO (2015). There has been a long standing scientific and technical consultation process between countries and the FAO in order to improve the definitions and enhance the comparability of data. From 1987 onwards, an expert level meeting organised in Kotka (Finland), with a periodicity of approximately 6 years, has had an important role in proposing common definitions in connection with the global forest resource assessments conducted by the organisation. These assessments have been carried out in collaboration with countries from all parts of the world and they have become an important driver towards global harmonisation of forest statistics. However, as shown in the 2005 report (FAO 2004) a lot remains to be done before forest statistics from different countries are really comparable.

At United Nations (UN) regional level, the joint UNECE/FAO Forestry and Timber Section, has served as an important source of information, data and

analysis. This information has described the forest sector in the UNECE region for more than 50 years. A cornerstone of the harmonisation process was the Temperate and Boreal Forest Resources Assessment (TBFRA). In collaboration with the FAO, the Section plays a pivotal role in the regular assessment of the state of forests in the pan-European region and contributes to the periodic global Forest Resources Assessment (FRA). Moreover, the scope of the FRA has changed regularly since the first assessment was published in 1948. The changing scope required the introduction of new attribute definitions.

1.2.2 United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Conference on Environment and Development (UNCED), better known as the Rio Earth Summit, was a key United Nations conference focusing on the global environmental challenges. Held in Rio de Janeiro in June 1992, the Earth Summit resulted in the following documents*: Rio Declaration on Environment and Development, Agenda* 21 *and Forest Principles*. Moreover, important legally binding agreements were opened for signature: Convention on Biological Diversity (CBD 2009), Framework Convention on Climate Change (UNFCCC 2009) and United Nations Convention to Combat Desertification (UNCCD 2012).

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty with the objective to "stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". The convention provides a framework for negotiating specific international treaties (called "protocols") that may set binding limits on greenhouse gases. As a follow up the Kyoto Protocol was signed in 1997, establishing legally binding obligations for developed countries to reduce their greenhouse gas emissions. One of the first tasks set by the UNFCCC was for signatory nations to establish national inventories of greenhouse gas (GHG) emissions and removals, which were used to create the 1990 benchmark levels for member countries to the Kyoto Protocol. According to the agreements, information should be provided annually from many different sectors; one of them being the land use, land-use change, and forestry (LULUCF) sector. A report by Cienciala et al. (2008) highlights the important role of NFIs in providing data for the LULUCF sector. The report also describes the processes towards harmonisation ongoing in Europe and identifies several remaining harmonisation needs.

1.2.3 Sustainable Forest Management

The Forest Principles is the informal name given to the Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of all types of forests. It makes several recommendations for the conservation and sustainable development of forests.

From the conclusions of the Earth Summit in 1992 and the new reporting obligations that followed, the workload at national level increased due to the many new international information needs. These new requirements placed an emphasis on the data provision mechanisms required to provide robust, statistically sound, current and long term information. As main source of forest resource information, NFI's are contributing to reach this goal. In particular, world regional processes such as the Montreal Process (2005) or Forest Europe (MCPFE 2007) define a set of Criteria and Indicators (C&I) for assessing the sustainability of forest management. This reporting exercise is quite demanding, in terms of individual countries capacity to report on the definition.

At pan-European level, from 1990 onwards, Ministerial Conferences on Protection of Forest in Europe (MCPFE) were regularly set up. The first Strasbourg Conference was a major step to initiate the incorporation of scientific data into political action to protect Europe's forests. At the Second Ministerial Conference, held in Helsinki in June 1993 agreement was reached the promotion of sustainable forest management, the conservation of biological diversity, strategies regarding the consequences of possible climate change for the forest sector, and increasing co-operation with countries in transition to market economies. At the Lisbon Conference in 1998 the Ministers decided to adopt a set of criteria and indicators (C&I) as a basis for international reporting on the sustainability of forest management in Europe. The set of quantitative and qualitative (descriptive) indicators was discussed and definitively adopted at the Ministerial Conference in Vienna in 2003 (the improved pan-European indicators for sustainable forest management, 35 quantitative and 17 qualitative indicators). A report titled State of Europe's Forest (SoEF) was produced in 2003, 2007, 2011 and 2015. In 2011, at the Ministerial Conference in Oslo (the process is now called "FOREST EUROPE"), countries committed to take a clear mission to advance the realisation of the shared vision, goals and 2020 targets to secure and promote Sustainable Forest Management (SFM) with the aim of maintaining the multiple functions of forests crucial to society (Oslo Ministerial Decision: European Forests 2020—Ministerial conference —Oslo 2011-Final declaration). Due to the 2012 convergence process at international level initiated by FAO, the most recent SoEF report was produced in 2015, close to the FRA 2015 report both using national data coming from the NFIs (Fig. 1.1). The majority of data was collected using a joint questionnaire called Collaborative Forest Resources Questionnaire (CFRQ), where only part of data concerns the pan-European process.

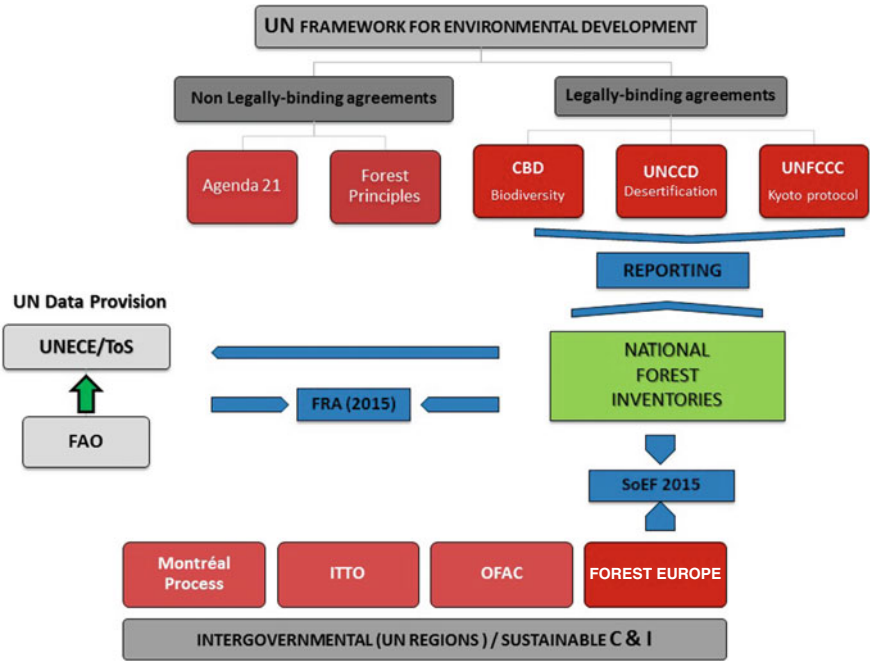

Fig. 1.1 International reporting in the forestry sector with a focus on Europe. Where the International Tropical Timber Organization is called ITTO and the Observatoire des Forêts d'Afrique Centrale, OFAC, the United Nations Framework Convention on Climate Change is called UNFCCC, the United Nations Convention to Combat Desertification, UNCCD, and the Convention on Biological Diversity, CBD

1.3 EU Forest Policy Framework

The need for the European economy to be more productive, innovative and competitive whilst using fewer resources and reducing its environmental impact has been widely acknowledged (EC 2014a). It is evident that Europe's forest sector, as part of the European green infrastructure (EC 2014b), can play an important role here and can contribute to tackling significant future social, ecological and economic challenges, such as unemployment, climate change and globalisation (WHO 2012). Yet, these challenges will also increase the demands on forests, which besides wood and energy production, include carbon sequestration, biodiversity conservation, water protection, landscape management, soil and nutrient regulation, tourism and recreation. Moreover, the competition for land use between traditional agriculture, biomass production, and forestry is expected to increase in the future (EC 2014c).

Forests represent the 33 % of the total land in Europe, excluding Russia (FOREST EUROPE, UNECE and FAO 2015). These forest areas are crucial component of the European landscape, with regard to biodiversity and management

of natural resources, mitigation and adaptation to climate change and a main contribution to ecosystem goods and services, among other roles (FAO 2010a, b). While European forest policy is cross-sectorial (Winkel et al. 2013), there is no mandate for working with forest issues directly and no coherent forest policy at EU level. Forests are indirectly part of several main EU environmental policies and legislations as highlighted in the new EU forest strategy for forests and the forest-based sector (COM 2013/659). Forests are also an integral component of the EU Habitats and Birds Directives, as about 46 % of the Natura 2000 Network of protected sites is covered by forest ecosystems (EEA 2012), and the EU Biodiversity Strategy 2020 has several targets where forests are particularly mentioned.

The EU supports SFM and the multifunctional role of forests as expressed in the EU Forest Action Plan and the Forest Strategy. Forests also play an important role in other existing EU policies, such as energy policy and Reducing Emissions from Deforestation and forest Degradation (REDD+) and rural development legislation. There is a continued need for forest assessment and indicators at EU level to support the development and implementation of a number of European environmental policies, where forests play a major role.

The formulation of forest policy demands relevant, harmonised, comprehensive and reliable data in order to achieve balanced and robust policies necessary for directing forest management. In addition, reporting obligations associated with EU forest-related policies and international agreements call for comparable data and information on Europe's forest ecosystems e.g. Millennium Development Goals on preventing deforestation and activities under the Kyoto Protocol, the CBD and UNFCCC.

NFIs are reliable sources of forest-related information. Nevertheless, due to the increasing demands by the forest and other related sectors there is a clear need to make data collection and analysis more efficient and harmonised, enhance interoperability, provide information for the main parameters on complete coverage maps and deliver the information up-to-date. Better knowledge on forest resources and their sustainable future supply can help predict the development of forest ecosystem goods and services. Thus forests can serve a broad range of affected stakeholders and create new opportunities for an innovative, sustainable and inclusive bio-economy in Europe.

Results from recent European NFIs show an increased forest area and growing stock in most surveyed European countries as detailed in the SoEF 2010 (FOREST EUROPE, UNECE and FAO 2011) and SoEF 2015 (FOREST EUROPE, UNECE and FAO 2015) reports. However, due to environmental, economic and social restrictions, only parts of the resources are available for timber supply. Moreover, the development of new techniques to use wood as fuel (e.g. wood chips and pellets) has enlarged the demand for wood (EC 2009). Parts of the trees that traditionally remained in the forest can now be harvested e.g. tree-top, branches and stumps, but these parts of trees are rarely estimated. Short rotation coppice is also planted specifically to rapidly produce biomass for fuel. In areas with a low forest cover trees outside forests (TOF) and hedgerows have become a possible source of

energy. But few countries are assessing wood resources on these areas and if any are, it is not at all in a harmonised way as shown in Chap. 2 of this book. Finally, a large part of the energy wood resource is composed of industrial residues and wood waste. Since many NFIs collect more information both on trees inside and outside forests, it could be possible to create harmonised methodologies necessary to estimate the total EU available wood resources from both within and outside forests in a near future.

Running from 2014 to 2020 with a budget of just over €70 billion, Horizon 2020 is the EU's new programme for research and innovation and is part of the drive to create new growth and jobs in Europe. Horizon 2020 is a core part of Europe 2020 the Innovation Union and the European Research Area and is responding to the economic crisis to invest in future jobs and growth, addressing people's concerns about their livelihoods, safety and environment and strengthening the EU's global position in research, innovation and technology (COM (2010) 2020). As a response to the new EU Forest Strategy (COM 2013/659) a Horizon 2020 funded project Distributed, Integrated and Harmonised forest information for bio-economy outlooks (DIABOLO) aims at: (i) strengthening the methodological framework for more accurate, harmonised and timely information derived from forest inventories and monitoring systems, that can be fed into the EU information systems; (ii) to support the development of EU policies and international processes relying on consistent forest information and (iii) to make innovative use of field-collected data and EC space-based applications of Earth observation and satellite positioning systems.

1.4 The Role of NFIs in Estimating the Potential Wood Supply

NFIs are the main source of information for characterising the state and change of wood resources overtime, making NFI data an essential component for generating projections on wood supply over varying climatic and management scenarios. In this section the policy needs and the role of NFIs for estimating potential wood resource availability at national and international scales will be described.

With the EU Renewable Energy Directive put forward, the climate change discussions and the post-Kyoto negotiations ongoing wood supply is an important issue in the light of rapidly growing demand for wood for all aspects including; carbon storage in forests, energy from forests and harvested wood products (EC 2014c). Woody biomass is an important renewable energy source and will play a decisive role in mitigating climate change. Hence in a future "low-carbon" society, wood fuel has a high potential to displace fossil fuels. The political questions NFIs have to answer at pan-European and at EU level are the following:

– How is the forest resource in Europe developing when different policy goals related to forests are implemented?

- Is it possible to ensure a sustainable provision of ecosystem services from forests even though climate change and social pressures increase?
- What are the consequences for forest management when implementing one or more forest related policy?
- What are the trade-offs in forest development and in the provision of the various services of forests when favouring one forest related policy goal over another (e.g. more biodiversity vs. more resources for energy)?

To address these questions, intensive monitoring on the status of forests is required, which goes beyond the borders of countries. Harmonising national level data and developing information systems to collect and analyse the results at European level are fundamental steps to the production of a sound European forest information system and the provision of future woody biomass availability scenario projections.

There are basically two different kinds of questions; "is it possible to …?" and "what are the consequences of (new policies)…?" Estimating the potential wood supply would help in answering some questions of the first type, while the second type is more about illustrating a probable development. To answer both types of questions, some scenario projection tools are needed.

In order to make a scenario projection describing the evolution of forests, two fundamental components are required: a description of the starting state of the forest and a model that describes what will happen with the forest over time. This development of the forest is driven by the bio-physical settings, the climate and interventions in the form of management and catastrophes. This in turn implies that the level and intensity of interventions must be formulated. If a potential is sought, it is necessary to find the intensity and structure that would yield the highest potential. One standard application is to try to find the highest possible, non-declining, harvest level under the restriction that the standing volume over time should not decrease. Often this harvest level is interpreted as the "potential wood supply", where the non-declining character and the preserved standing volume are used as sustainability criteria. Of course different restrictions can be imposed in the assessment, for example by taking into account accessibility issues.

If the aim is to investigate the consequences of a certain policy intervention, analyses of the most probable development following the intervention is required. In many cases the relevant question is: what forest management practices (in terms of silviculture and harvest) would be the result of the policy intervention? Often NFI data is not sufficient for this kind of analyses. In addition, socio-economic information from other sources is required.

1.4.1 ENFIN Harmonisation Methodology

In many countries, information systems have been developed at the national level for national policy needs and are now increasingly being integrated into major

international reporting mechanisms. Due to the different historical backgrounds, varying environmental conditions and NFI objectives, NFIs have adopted different basic definitions and methodologies, leading to inconsistencies and lack of comparability in international reporting (Gabler et al. 2012).

A distinction is often made between harmonisation and standardisation (Köhl et al. 2000). Standardisation implies that all parties need to apply the same definitions, and possibly even field protocols, whereas harmonisation only prescribes that a final conversion from the local to the reference definition be made. Thus, harmonisation leaves a certain freedom to parties to use existing time series of data and definitions rather than establishing new or parallel data acquisition systems. This is important in times of expanding international information requirements, since standardised protocols to every new agreement would be very costly. This flexibility is also important to adapt data collection to information requirements that tend to change slightly over time such as the Good Practice Guidance (GPG) of Intergovernmental Panel on Climate Change (IPCC). On the other hand, standardisation is the most accurate way to have comparable data over time and between countries.

In 2003, the European NFIs decided to collaborate in order to enhance comparability of forest information by founding the European National Forest Inventory Network (ENFIN). Being aware of activities related to assessments, reporting and analysis by international institutes and organisations focused on Europe is essential. These results in the ENFIN group, collaborating with organisations such as FAO, UNECE, FOREST EUROPE and European Commission, which can benefit of and be complementary to ENFIN's efforts is essential. The overall objective of ENFIN is to promote NFI's as comprehensive monitoring systems by collecting harmonised information on forest ecosystems, forest resources and land cover/land use/landscape changes. The ENFIN group decided therefore to work on a sound and clear harmonisation process with two objectives. The first one is to allow each country for keeping its data collection system in line with its national needs and specificities and to adapt it in line with new policy requirements both at national and international levels. The second objective is to move forward towards harmonisation, being aware that a lot of data are not comparable despite a lot of harmonisation processes from decades at international level such as the FAO driven one.

1.4.1.1 COST Action E43

In order to respond to the need for harmonised information at the European level, ENFIN members initiated an EU COST Action project, to work towards the goal that NFIs would be able to provide comparable forest resource information (COST Action E43 2010, 2010). COST Action E43 was launched in June 2004 and 27 European countries joined the action. The COST Action was titled "Harmonisation of National Forest Inventories in Europe: Techniques for Common Reporting". The Working Groups of the Action collected, analysed and distributed information in currently applied definitions, measurement practices and methods to improve the

dialogue between NFIs on one hand and between NFIs and NFI data users on the other. The main objective of COST Action E43 was to harmonise the European NFIs in such a way that inventory results were comparable (Tomppo et al. 2010). A common set of precise and unique reference definitions were the basis for this harmonisation.

Existing definitions at national and international level often refer to and rely on terms that leave room for interpretation. For example, the definitions of forest, other wooded land (OWL), growing stock, and numerous other definitions for biomass according to FAO (1998), UNECE/FAO (2000), IPCC (2003), FAO (2004) and FAO (2012) frequently use terms that are either not precisely defined or not defined at all. In particular, these definitions often refer to trees or shrubs. Although the FAO (1998, 2004, 2012) and UNECE/FAO (2000) specify trees and shrubs in their terms and definitions, these definitions may fail when distinguishing trees from shrubs as often required in NFIs. However, it is important to emphasise that, due to variations in nature, the distinction between trees and shrubs can be difficult. Moreover, existing definitions often employ terms that are not defined for the purpose of reporting, primarily at the international level. This is particularly true for the distinction of tree elements, i.e. roots, stump, stem, branches, bark, foliage, but also for variables such as height, crown cover and for the characteristics of living and dead, standing and lying, and unusually shaped trees which are essential for estimating the resource of wood. Since the individual tree is the basic element of any forest resource assessment, the clarification of tree-related terms was an important achievement of COST Action E43 to harmonise common reporting of NFIs. Based on a review of existing definitions and on the identification of the requirements for harmonised reporting, common tree-related definitions have been established (Gschwantner et al. 2009).

The secondary objective of COST Action E43 was to support new inventories in such a way that inventories meet national, European and global level requirements in supplying up-to-date, harmonised and transparent forest resource information, and to promote the use of scientifically sound and validated methods in forest inventory designs, data collection and data analysis. More than 30 countries and institutions, mainly from Europe, and multiple international institutions joined the Action, initiated in 2004 (McRoberts et al. 2012).

The published methodologies of establishing reference definitions and bridges to enhance harmonisation opened up the possibility to produce harmonised data at European level.

1.4.1.2 Harmonisation Steps

The methodology developed within COST Action E43 considered four steps for harmonisation (Vidal et al. 2008). The first step was to establish a screening exercise to assess the situation nationally. To be able to speak about improving the comparability of data it is necessary first to have a clear "**state of the art**". For that purpose, the way of working of COST Action E43 was to design a questionnaire by

working groups (WG) on variables of interest. This questionnaire was discussed, amended and validated by all countries participating in the action. This process was an iterative process with bilateral exchanges, in order to have a clear common understanding of national situations and concepts and definitions used.

The second step was to make an **analytical decomposition** of each definition to be harmonised. By analytical decomposition it must be understood to individualise and describe the main criteria necessary to define the concept. Let's take the example of definition of a forest. The main criteria used are minimum area, crown coverage and land use. To these criteria are associated thresholds. With the example of forest, the thresholds associated to minimum area could be 0.1 ha or 0.5 ha or also 1 ha and thresholds associated to minimum crown coverage could be 5, 10 % or even 30 % depending on the countries.

The third one is to build what was called a **reference definition**. In light of the questionnaire results and the analytical decomposition, the COST Action E43 members discussed and agreed upon a common definition which is possible to be accepted by everybody and the closest possible to the way of working of each. This is also an iterative process to reach a consensus.

The fourth step of the harmonisation process is to build **bridges** (Ståhl et al. 2012) between national definitions and the agreed reference definition. The analytical decomposition of the criteria and thresholds during the process formed the basis of this work. Information on the criteria and thresholds assists in the identification of where the differences are and how to build a bridge to transform national data into comparable data.

This way of working is diverse and challenging depending on the context and differences between the definitions. However, this step-wise methodology provides a framework towards harmonisation.

1.4.1.3 Requirements for Successful Harmonisation

For harmonisation to be successful, several factors need to be considered. Firstly, the definitions involved (both the reference and the local definition) must be concise and sharp so that it is clearly understood what are the differences between them. One "side-effect" of this first step is also to have a clear picture of the non-comparability of data contained in international reporting from producer of information but also from data user sides. This awareness is an essential clarification step in order to enhance the willingness to harmonise data. Secondly, local data or information with adequate accuracy must be available. Thirdly, methods to convert from the local to the reference definition must be developed and then applied depending specifically on the context. Finally, bridges can be seen as means to cross over from "islands" of local definitions to a reference definition "mainland". The objective is to propose a structured approach to develop bridging functions from different sorts in line with different situations.

1.4.2 European Framework Contract

The above mentioned methodology was applied in helping the EC Joint Research Centre (JRC) to set up a harmonised forest database as requested by the EU forest strategy document (COM 2013/659). In this respect, in 2007 the JRC launched a four-year Framework Contract (FC) for provision of forest data and services. A consortium of ENFIN members was successful in securing this contract. The main outputs of this first FC were: (i) the provision of harmonised tree species distribution data from European NFIs with the joint JRC-ENFIN publication of a European tree species atlas as an output (San Miguel et al. 2016) (ii) the validation of the JRC European forest map with more than 2 million NFI forest/non forest plots and (iii) a harmonised basal area statistical estimation based on the 50 × 50 km Infrastructure for Spatial Information in the European Community (INSPIRE) grid with a satisfactory confidence interval. After this four-year FC recognised by the European Commission (EC) as a demonstration project, a second FC was signed in 2011 in order to continue to provide data and services to the JRC on a voluntary basis. Initial results from this second FC include (i) a harmonised method for calculation of biomass with a common methodology accepted by mainly all European countries (ii) an open source model on estimation of volume and growing stock applicable under different climatic and forest management conditions all over Europe. This model is called European Forest Dynamic Model (EFDM) and is under development.

1.4.3 Projection Tools at National Level

Nordic countries were not only the first to initiate sample-based NFIs in the twentieth century but also in trying to assess the potential availability of wood as an industrial raw-material. This information was required to provide a sound basis for the establishment of forest industries. With the increasing interest in the forest and the forest resources, not least as a biomass source for energy use, a growing interest in assessing the potentials and the possible development of the forests is being observed. Over the last decades computerised systems have been developed to predict wood supply across Europe. In many cases these projection systems are based on NFI data and are applicable at both local and regional level. However, in Eastern countries the implementation of sampling based NFI designs has begun in recent decades, with official projections frequently based on forest management plans. As the demand for projection systems arose within countries, these are normally developed with a national scope being subject to the differences in NFI layouts and designs. As a result, the application of a specific system across countries is difficult and even projections obtained using different tools are not easily comparable.

In Europe many different forest management systems coexist, yielding differently structured forests. The two main groups of forest structures are even-aged forest and uneven-aged forests. Even-aged forests are the result of tract harvesting system with regeneration, followed by thinning and clear felling as the basic management cycle. It could also be the follow up management action after a natural disaster such as a forest fire. The uneven-aged forests, result from management systems that are based on continuous-cover silvicultural principles or from no management at all. Adding to this, species mixtures also contribute to increasing the complexity of forests systems. Countries which had a major interest in the forest sector and long experience in the use of NFI data, became forerunners in the development work. Sweden and Finland, characterised by even-aged homogeneous forests under active management, became leading countries, while for countries such as France, Italy and Spain where the diversity in soils, climate and forest conditions prevail, the development of projection systems has proven difficult. In Spain, such efforts resulted in the development of many forest projection tools intended to be used on a local scale (Bravo et al. 2011).

Many projection systems are based on a stand-wise description of the forest, examples of which are found in Czech Republic, Bulgaria, Hungary, Ireland and Lithuania. Irrespective of the description of the forest, some kind of a growth model must be applied in order to express the development of the forest under a pre-defined management. These growth models can be developed using NFI plot data, experimental plots or a combination thereof. Permanent as well as temporary plots can be used to develop growth models as demonstrated by examples from Finland, Sweden and Portugal. Fundamentally, the use of a model to project the future development of a forest means that we are extrapolating historical patterns, as estimated from historical data, into the future.

Individual NFI plots are the basic calculation unit in many modern projection tools, currently applied or applicable to even-aged forests. The initial state of the forests is described by a set of plots, each one characterised by a number of attributes as tree species, tree diameter and height or basal area and tree dominant height. The models used for illustrating the dynamics of the forests are applied directly to the plots representing the forest. A multitude of growth models are at hand, some of them are area based whereas others express the development of individual trees. Examples of this type of systems are the Swedish Heureka-system (with its predecessor HUGIN) (Wikstrom et al. 2011) and the Finnish MELA (Redsven et al. 2012).

In turn, uneven-aged forests are often described by using the distribution of stems by diameter-classes. Most projection tools developed for these types of forests are not intended for national application, but for stand level analysis. However, there are a few projection tools based on regional aggregates of plots either by age, diameter or tree classes, e.g. in Austria or France. Regional aggregates by diameter classes could contain trees with the same diameter, but from very different stands, implying that the development over time could be significantly different, due to varying competition from other trees and lack of observed variation

in natural conditions. Long-term simulations using this kind of models always require careful analysis.

Many national studies were recently conducted to address the question of wood available for energy in European countries and in other parts of the world (FAO 2008). Fewer studies characterise the total available wood split into the different usage categories: saw timber, other industrial wood and energy wood. One difficulty for the comparability of the results at international level is the variety of definitions describing wood assortments, which frequently depend on the species, the industry and the market. A recent report by the UNECE/FAO Timber Section showed that there is a potential to supply more wood from the European forests (Hetsch 2009). However, the authors highlight that the results used in the report suffer from diversity of sources and definitions, which limits the comparability of the results between countries. For example, the "potential supply" is not a clear concept. It could mean that the wood is technically harvestable, but also that it is environmentally, economically and socially acceptable. NFIs can provide information on the technical availability, sometimes taking into account environmental factors, but these parameters differ from one country to another, which makes it difficult to compare or sum the results.

1.4.4 Projection Systems at International Level

Over the years, some efforts have been put into trying to establish European level forest dynamics analyses based on a more or less harmonised data structure. One of the first attempts was the so called IIASA-model developed in late 1980s, and used to make forest analyses at European level including the European part of the former Soviet Union (Nilsson et al. 1992). This projection tool was an area based matrix type model that was calibrated using differing wood quality and stand structure data sets. For some countries available NFI data and in other cases official statistics and yield tables were used. The basic concept was later moved into the European Forest Information SCENario Model (EFISCEN) model (Nabuurs et al. 2007; Sallnäs 1990; Schelhaas et al. 2007; Verkerk et al. 2011) developed at the European Forest Institute (EFI) which kept being improved and has been applied in a number of studies, many of them at European level. To carry out these studies, in many cases supported by national NFIs, the EFI built up a European data base from which the model can be calibrated and run. The EFISCEN projection system has served as the "forest part" of some of the most recent forest sector outlook studies, for example EFSOS-II. The original model concept was designed to be applied on even-aged forests, and it is still of limited application to uneven-aged forests. More recently, the JRC project EFDM (European Forestry Dynamics Model) (Packalen et al. 2014) aimed to further develop the model concept of the IIASA and EFISCEN

models. The project is carried out in close collaboration with the national NFIs under the coordination of ENFIN so that the model can be based on NFI plots. The approach is based on the premise that information from NFI plots measured or assessed in two consecutive points in time are aggregated into the matrices that constitute the core of the model. However, opinions among countries vary regarding the provision of detailed NFI-based data for European wide analyses. While some countries publish detailed data on the Internet, others are more restrictive due to national confidentially agreements. Therefore, detailed work with NFI data is carried out at a national level, while the aggregated information contained in the matrices can be used on a pan-European level. Making pan-European analyses also demands "national" information about management and other parameters reflecting the socio-economic conditions in the country. A successful pan-European analysis, especially in the domain of policy impact analyses thus presupposes a close cooperation between the analytical body and national experts. That is one of the goals of the future European Commission's European Forest Bureau Network (COM 2013/659), a joint NFI experts and stakeholder network developing harmonised criteria for NFI data.

Since around half of the EU forests, mainly in the South of Europe, can be regarded as uneven-aged the Joint Research Centre also decided to invest in developing a European projection tool, able to make projections for these forests, based on an alternative concept. The approach is to model the development of areas, represented by NFI-plots, instead of trees, with the areas (plots) characterised by volume and stem-number (Sallnäs et al. 2015).

1.5 COST Action Usewood

In 2010, the ENFIN group proposed a new COST Action focused on wood resources estimation and called: "Improving Data and Information on the Potential Supply of Wood Resources. A European Approach from Multisource National Forest Inventories". The Memorandum of Understanding of this action focused on the following: "The question of availability of wood in Europe on a sustainable basis is highly relevant to define global change mitigation strategies and targets for biomass energy as adopted at national and European level, and to support the proposal of an increased use of wood as a post-Kyoto decision. Future scenarios at EU-level highlight a deficit of wood supply compared to wood consumption. Major issues to be clarified are the potential supply of tree biomass, trees outside the forest, and the economic, social and ecological conditions, which will determine the wood supply. The COST Action aimed at improving information and methodologies on the potential sustainable wood supply using NFI data to reduce the given uncertainties. Such harmonised information is urgent to improve the calculation basis for decision makers in the forest, environment, and in the wood and energy sectors" (Cost Action Usewood 2014).

The objectives of this COST Action were:

- to improve and harmonise data and information on the potential supply of wood resources at European level as well as to compare and disseminate the methodologies including remote sensing techniques, definitions and results of wood resource studies in European countries
- to develop best practices and harmonised guidelines in this field
- to exchange information on difficulties and challenges and find harmonised solutions in e.g. modelling taper curves and assortments of trees or in assessing trees outside forests, to help countries to improve their expertise in special modelling or remote sensing techniques in capacity building of these technical areas, to contribute to build a comprehensive and reliable picture of potential wood supply as an input to energy, environment, forest policy making, and wood industry decision making.

The objectives of the Action were to achieve the following three basic mechanisms. Firstly, the scientific program including its work plan, time table and deliverables were elaborated with specific consideration to the production of results. Secondly the large body of ongoing work on assessing and using wood supply both at national and international level would ensure that the Action is based on substantial scientific activities. Thirdly the collected expertise involved in the Action would guarantee both linkages to the data providers and the research communities working within the topic and the use, and dissemination channels of the action.

1.5.1 COST Action Usewood Working Groups

The focus of Working Group 1 (WG1) was on available field data and information from the NFIs, as well as information on sampling design and estimation techniques for wood resources. The work further developed the methodology for the harmonisation of NFIs performed under the COST Action E43. New variables are discussed, such as Forest Available for Wood Supply (FAWS), quality of wood, increment, fellings, and mortality, Other Wooded Land (OWL) and Trees outside Forest (TOF) were investigated and harmonised definitions developed. The major question to investigate was, how much wood is available at present (taking age classes and diameter thresholds into account), and in collaboration with WG3 how much will be available in the next decades. Although the question is not entirely addressed, recommendations for statistically sound data assessment and estimation techniques are given. The effects of different approaches on the results are also presented.

Working Group 2 (WG2) investigated methods for improving estimates of wood resources by integrating remotely sensed and NFI field data. The overall aim was to develop scientifically sound practices for assessing tree biomass and other forest resources, inside and outside forests, in support of periodic and rapid updates of

estimates at NUTS3 and regional levels. WG2 provided an overview of the extent to which NFIs use remote sensing data, tools, and methods (e.g. satellite and airborne imagery, optical area, LiDAR and radar data). The role of remote sensing in improving the efficiency of sampling designs and the precision of estimates was considered. Methods to estimate forest attributes, such as biomass and volume, for small areas and to map their spatial distribution was discussed and evaluated. Special attention was devoted to error estimation, detection of clear-cuts and other changes in forest resources for the purpose of estimating change in biomass.

Working Group 3 (WG3) worked on guidelines for harmonised forest information for better exchange of information between inventory data of standing volume and consumption statistics which follow market needs and developments. The WG3 identified availability of production and trade statistics and the potential to improve information for a better transfer from NFI -data to consumption data.

1.5.2 Working Group 1

This book is a product of WG1 work. One of the main actions of WG1 pursued to harmonise data and information on the potential sustainable wood supply around Europe. Within this framework, the main goal of WG1 was to increase the knowledge about different national definitions to promote the harmonisation of the assessments and estimation techniques of current and changing wood resources based on NFI data.

To achieve the aforementioned goal more efficiently the WG1 was organised to four subgroups that focused on four thematic areas: (1) Forest available for wood supply (FAWS); (2) Stem quality assortments; (3) Change estimation; and (4) Other Wooded Land (OWL) and Trees Outside Forest (TOF) (Fig. 1.2).

The way of working within the WG1 was elaborated in four steps:

1. An analyse of existing international definitions for each variable of interest was conducted by sub-group and the weaknesses of international definitions identified
2. A questionnaire was built in order to have a clear picture of how definitions were applied nationally
3. Reference definitions were firstly discussed and proposed by each SG. The definitions were then amended and validated in plenary by all COST member countries
4. A country report (CR) was foreseen and the structure and template of such a CR was discussed and approved by the full WG1.

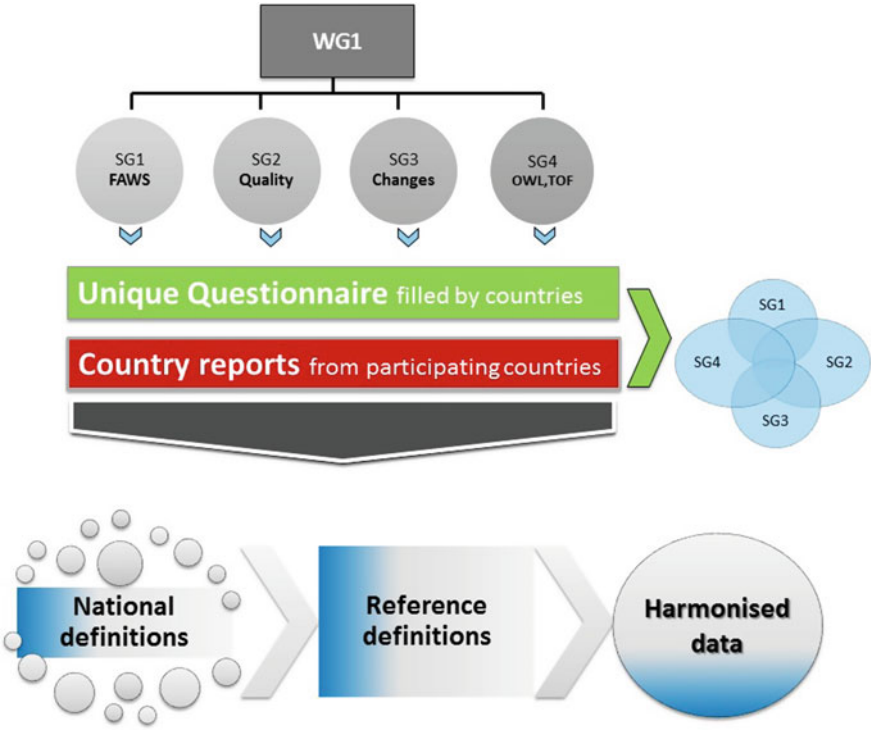

Fig. 1.2 Structure of COST Action Usewood WG1 and the working sub-groups (SG)

After four years of work and cooperation, these four subgroups have compiled a huge amount of information about wood resources assessments, estimations and national definitions at European level through country reports (CRs) and questionnaires. The analysis of all this information based on the collaboration between international research groups provide interesting results to further understand the diversity of wood resources and estimations in Europe. This volume contains (i) a general overview of the main findings (ii) obtained common reference definitions established and (iii) the contents of the CRs on the assessment, availability and use of wood resources sent by the participating countries. Thirteen non-COST countries joined our initiative and provided a CR as far as possible in line with European questions and specifications.

Taking into consideration the broad-scale goal of the book it was important to collect as large a number of CRs as possible. In total 40 country reports were completed, 28 of which were from COST member countries plus the USA and due to the international focus of this book a further 11 non-COST member countries also submitted country reports (Fig. 1.3).

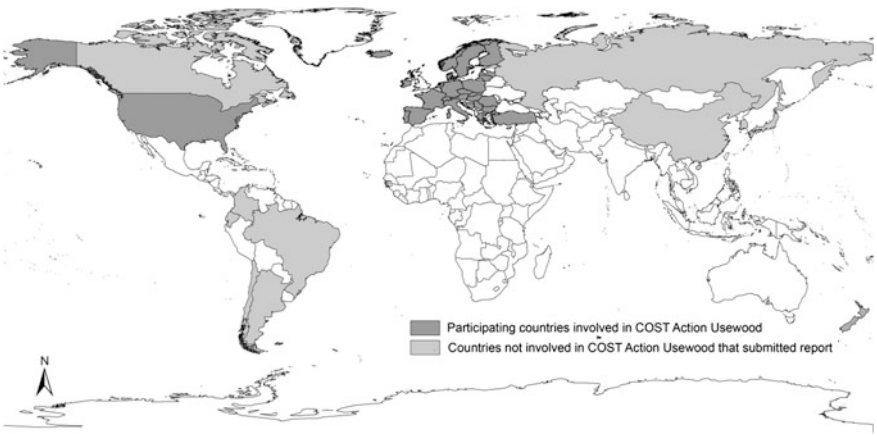

Fig. 1.3 Countries submitting a report for this book

1.6 Structure of the Book

This introductory chapter one of the book provides an overview of the motivation of COST Action Usewood and outlines the necessity of the international provision of wood resources information in a harmonised context. After briefly describing the history of wood resource assessment in Europe, this chapter illustrates the function of NFIs as forest data providers to estimate wood resources at national and international level. Finally, the objectives and structure of COST Action Usewood are described. Chapter 2 summarises the synergies found regarding wood resource definitions, assessments and estimation focus in the four main subjects of WG1: (i) forest available for wood supply (ii) stem quality assessment (iii) change estimation and (iv) other wooded land and tree outside forests estimation. This information is based on the material from country reports and questionnaires supplied by the participating countries during the COST Action.

Chapters 3 and 4 present an overview of the harmonisation progress regarding wood resource assessment. Chapter 3 focuses on the construction of reference definitions, presenting the agreed definitions by WG1 for the four main subjects. Chapter 4 concentrates on the bridge building concept, showing some applications and examples accomplished during the COST Action that facilitate the estimation of wood resources consistent with the reference definitions.

Finally, focused on the information from non-COST member countries, Chap. 5 presents an overview of the wood resource assessment beyond Europe and the feasibility of these countries to adopt the COST Action Usewood reference definitions proposed.

After Chap. 5, 40 individual reports are presented. These reports were submitted voluntarily by countries and describe national wood resources, methods and estimation techniques together with related reference definitions. Most of the reports

follow the same structure. This includes a first part comprising a brief history of the NFIs, sampling methods, data collection as well as processing, reporting and use of results on wood resources. A second part contains a description of the land classification, the variables used to estimate wood resources and the particular assessment of wood resources. The third part describes the different methods to assess and estimate the forest available for wood supply, wood quality assortments, changes (increment and drain) and other Wooded Land and Trees outside Forests from national forest surveys.

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