Chapter 5
Wood Resources Assessment beyond Europe

Laura Hernández, Iciar Alberdi, Ronald E. McRoberts, David Morales-Hidalgo, John Redmond and Claude Vidal

5.1 Introduction

Forest ecosystems provide wood and many other services that contribute significantly to human well-being at local, national, and global scales. These contributions include the conservation of soil and water resources, mitigation of the effects of global climate change, conservation of biological diversity, improvement of urban living conditions, protection of natural and cultural heritage, subsistence resources for many rural and indigenous communities, generation of employment, as well as

L. Hernández (✉) · I. Alberdi
National Institute for Agriculture Research, INIA-CIFOR, Madrid, Spain
e-mail: hernandez.laura@inia.es

I. Alberdi
e-mail: alberdi.iciar@inia.es

R.E. McRoberts
Northern Research Station, U.S. Forest Service, Washington , USA
e-mail: rmcroberts@fs.fed.us

D. Morales-Hidalgo
National Forest Monitoring and Assessment Programme, Forestry Department, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
e-mail: David.Morales@fao.org

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

C. Vidal
European Commission, JRC-IES, Ispra, Italy
e-mail: claudevidal2@gmail.com

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

C. Vidal et al. (eds.), *National Forest Inventories*,
DOI 10.1007/978-3-319-44015-6_5

recreational opportunities (MEA 2005). Due to the importance of forests for humanity, the evolution of the world's forest functions and services, are a major concern in international agreements and processes that address environmental and development issues such as the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), the United Nations Forum on Forests (UNFF), or, the Sustainable Development Goals (SDGs).

Because woody biomass is an important renewable energy source and plays a decisive role in mitigating the effects of climate change, the issue of the availability of wood is emerging as a relevant post-Kyoto decision (COST Action Usewood 2014). Accordingly, from national to global scales, production of better information on the quantities of wood available has turned out to be of importance for assessing sustainable management decisions in forestry policy-making. Additionally, the majority of these agreements require substantial amounts of harmonised, comparable and accurate information from the parties to assess overall progress, compliance with obligations, as well as to determine the next steps of the agreements (Vidal et al. 2008; Ståhl et al. 2012).

For these and other national and international agreements that focus on sustainable environmental and forestry strategies, monitoring of forest resources has become critical for countries (Holmgren and Persson 2003; FAO 2014). The most important sources of forest data are NFIs. They have been established in many countries and provide accurate and representative information on forest attributes obtained mainly from field measurements but also from remote sensing (Cienciala et al. 2008; Tomppo et al. 2010; FAO 2014). The importance of field-based NFI has long been demonstrated through forest resource assessment (FRA) reporting, both through the value of reported inventory results and the identification of serious data gaps in countries where these inventories do not yet exist (McDicken 2015). In fact, the latest global FRA reports that forest resource data are currently generated at a greater frequency than any other time in history. Although much of the necessary information at country level is lacking in the tropics and in low-income countries, particularly in Africa, approximately 77 % of the world's forest area is currently covered by NFIs (FAO 2015). Consequently, as result of the important investment by governments in recent years to better understand forest resources, the level of availability and reliability of forest information at the global scale is greater than in previous periods (FAO 2001; Saket 2002).

The monitoring of forest resources has a long history (FAO 2014), where different approaches have been implemented for data collection during the last centuries. However, systematic forest assessments based on statistical sampling methods began in the early twentieth century (McRoberts et al. 2010). As Fig. 5.1 shows, the earliest NFIs were established at the beginning of the twentieth century in the European Nordic countries including Norway, Sweden or Finland as well as in the United States of America. Since then, new NFIs have been gradually established around the world, particularly in many European countries after World War II and in the 1960s (e.g. Germany, Austria, France, Spain or Portugal). The significant increase in NFIs developed since 2000 can be attributed to the important demand for forest information for international reporting requirements as a follow up of the 1992 Earth Rio Summit (e.g. Brazil, Canada, Great Britain, etc.). The noteworthy increment of NFIs during the last decade is also partly due to support from the National Forest Monitoring and Assessment (NFMA) programme of the United Nations Food and Agriculture Organization (FAO) carried out in a growing number of countries since 2000 (Saket et al. 2010). What started as a series of pilot projects has now developed into full scale NFIs in eighteen countries such as Brazil, Peru or Ecuador (see the corresponding country reports in this book for more detailed information), while another seventieth countries are expected to complete their firsts NFIs in the next two years (FAO 2016). Although today most countries conduct sample-based inventories, traditionally, national forest information was gathered by aggregating data from stand level inventories designed for management planning objectives (Tomppo et al. 2010; Fig. 5.1). Until recently, these systems

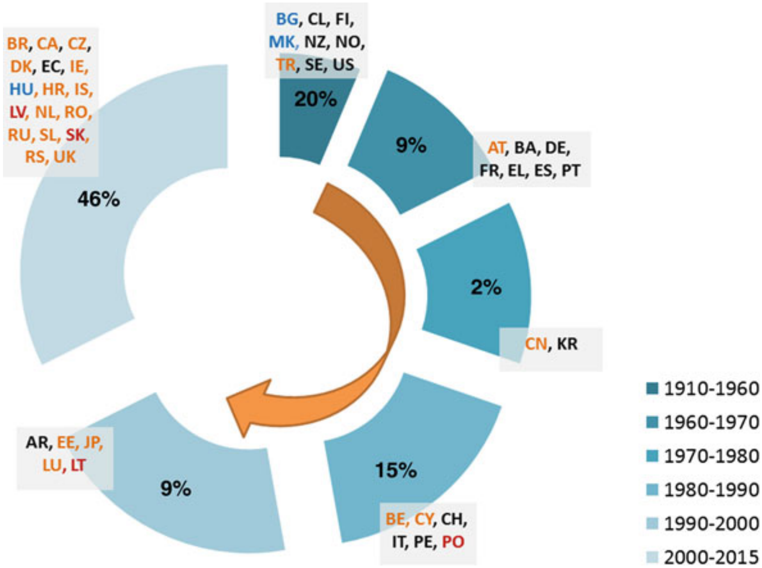

Fig. 5.1 Chronology describing the introduction of national forest surveys globally. (Note: taking into account the 46 participating countries in COST Actions E43 and Usewood, the percentage figures on the graphic detail the proportion of countries introducing forest surveys in the stated time period). The country abbreviations are located in the period where the NFI were first implemented, if that is the case. Countries with abbreviation in *black* represent those countries with NFI. Countries with abbreviation in *orange* represent those countries with previous FMPs that now have implemented a NFI. Countries with abbreviation in *red* have both FMPs and NFI ongoing. Countries with abbreviation in *blue* represent those countries with present FMPs. Countries abbreviations are the followings: *AT* Austria, *AR* Argentina, *BR* Brazil, *BE* Belgium, *BA* Bosnia- Herzegovina, *BG* Bulgaria, *BR* Brazil, *CA* Canada, *CN* China, *CL* Chile, *HR* Croatia, *CY* Cyprus, *CZ* Czech Republic, *DK* Denmark, *EC* Ecuador, *EE* Estonia, *FI* Finland, *FR* France, *DE* Germany, *EL* Greece, *HU* Hungary, *IS* Iceland, *IE* Ireland, *IT* Italy, *JP* Japan, *LV* Latvia, *LU* Luxemburg, *LT* Lithuania, *NL* Netherlands, *MK* Macedonia, *NZ* New Zealand, *NO* Norway, *PE* Peru, *PO* Poland, *PT* Portugal, *KR* Republic of Korea, *RO* Romania, *RS* Serbia, *RU* Russia, *SI* Slovenia, *SK* Slovak Republic, *ES* Spain, *SE* Sweden, *CH* Switzerland, *TK* Turkey, *UK* United Kingdom, *US* United States

based on Forest Management Plans (FMP) were particularly characteristic of Eastern European countries, but now some of these countries have also introduced statistical NFIs running in tandem with the FMP surveys, for example, Lithuania and Slovakia. Furthermore, in recent years NFIs have incorporated novel technological improvements in the form of remotely sensed data for increasing speed and cost/efficiency (McRoberts et al. 2002; McRoberts and Tomppo 2007). Although remotely sensed data cannot completely replace ground sample data (McRoberts et al. 2010), among other qualities, they can facilitate construction of accurate maps of forest attributes as well as access to the forest information in remote regions.

Similarly, the information recorded in the NFIs has evolved since the beginning of forest monitoring. Traditionally, NFIs focused on the productive capacity of forests because no other forest benefits or uses were considered (Holmgren and Persson 2003). Assessing growing stock, increment of stem-wood, wood supply and biomass of living trees were the main goals at that time. However, with the increasing concern for global deforestation (Lanly 1982; FAO 1995), the impacts of climate change (IPCC 2007) and the recognition of the importance of forests as biodiversity reservoirs (CBD 2009) and carbon stores (UNFCCC 2009), the scopes of NFIs have been enlarged and information for new variables such as deadwood, forest health, non-wood forests products and litter is now collected as well as their change assessed (Cienciala et al. 2008; Corona et al. 2011; Alberdi et al. 2014). Furthermore, forest information now includes more key aspects of sustainable forest management, comprising a three dimensional scheme of data collection: *resources* (the extent and state of the resources), *users* (who is using the resources) and *use* (how the resources are used and managed) (Morales et al. 2014).

In addition to the extensive, transparent and comprehensive data on forests required nowadays for reporting under international agreements, comparability of the submitted inventory estimates is yet to be achieved (McRoberts et al. 2010). Lack of comparability is a consequence of the diversity of the NFI definitions, sampling designs, plot configurations, measured variables and measurement protocols. The harmonisation process focuses on definitions, estimates, and comparisons among countries as a means of facilitating international reporting processes. Harmonisation has received increased attention in recent years by international institutions such as the Intergovernmental Panel on Climate Change (IPCC) and the NFMA program conducted by FAO (Saket et al. 2010). However, the most important efforts directed toward harmonisation of NFI estimates and definitions has been conducted by the European National Forest Inventory Network (ENFIN) in the framework of COST Actions E43 (Tomppo et al. 2010) and Usewood (Vidal et al. 2016). Although considerable progress has been made in developing methods to facilitate harmonisation of definitions and assessments (see e.g. Vidal et al. 2008), substantial work still remains in this field.

Chapters one to four described the harmonisation methodology developed by European COST member countries participating in the COST Actions E43 (2010) and Usewood (2014). The active participation of the US and other non-COST member countries in both COST Actions demonstrates a high level of interest in this harmonisation approach as a benchmark beyond Europe. Twelve NFIs from non-COST member countries contributed to this book in providing a country report, including: Argentina, Brazil, Canada, Chile, China, Ecuador, Japan, New Zealand, Peru, Russia, South Korea and the US. This chapter summarises the diversity of sampling methods, definitions and wood resource assessments (focused on forest available for wood supply, stem quality, change estimation and other wooded land and trees outside forest) of these countries. The differences and similarities among these and the European COST member countries are discussed. Because the countries contributing to this book account for almost 70 % of global forest area (FAO 2015), the analyses provide a global overview of the current state of the potential harmonised assessment of wood availability and use.

5.2 Diversity of Main Features of NFIs from Non-COST Member Countries

As expected, the great diversity of biomes, ranging from tropical to boreal, and corresponding forest attributes characterising the countries analysed, has led to substantially varying sampling designs and plot configurations (Table 5.1). However, a significant increase in the uniformity of fundamental NFI features such as statistical sampling designs and permanent NFI networks has been observed (FAO 2001; Tomppo et al. 2010). In fact, any of the countries analysed still relies on the aggregation of stand management inventories information as the source for national forest information. Probability sampling techniques facilitate estimation of sampling errors (Lawrence et al. 2010) and will further improve accuracy and reliability of data and information on forest resources from national to global scales. Regarding continuity of NFIs, nine of the analysed countries use permanent sample plots while three (Argentina, Ecuador and Brazil) which are currently developing their first cycles also expect to do so. Continuous monitoring inventories allow countries for assessing forest resources and cover changes over time as well as for addressing international information required by processes such as UNFCCC and Reducing Emissions from Deforestation and Forest Degradation (REDD+). Inventory cycles are typically either 5 or 10 years, although the Chilean National Forest Ecosystems Inventory (NFEI) uses a 4-year cycle (Table 5.1). In addition, Chile and Peru use annual inventories for which 20–25 % of plots are measured each year. This design is very suitable for reporting annual forest changes as required by some international commitments.

Most NFI sampling designs include systematic components based on two-dimensional grids. However, due to the high diversity of forest covers, biogeographical regions or administrative provinces comprised (e.g. China), the grid spacing may vary from 1 × 1 km to 50 × 50 km, even in the same country (see Table 5.1). Half of the countries use cluster sampling in which multiple plots (from 3 to 8) are established in close spatial proximity. Contrary to European NFIs (Lawrence et al. 2010) where concentric circular plots are more common, half of the

Table 5.1 Features of sampling based designs used by NFIs from non-COST member countries

Country	Spacing grid/cluster (km)	Strata criteria	Number of field plots per cluster	Type of plots	Plot criteria	Permanent plots/proportion of plots	Last NFI cycle	Current/future cycle	Cycle periodicity
Argentina	10/20/50/18	Phytogeogra-phical regions	3/5/8	Circular/Rectangular	Phytogeogra-phical regions	?	1998–2005	?	?
Brazil	20 × 20	–	4	Rectangular	–	?	–	2012–2018	5
Canada	20 × 20 to 40 × 40	Terrestrial ecozones	1	Square	–	1	2000–2006	2008–2017	10
Chile	5 × 7	–	3	Circular	–	1/4	–	2015–	4
China	1 × 2 to 8 × 8	Provinces	1	Square, rectangular and circular	Provinces	1	2009–2013	2014–2018	5
Ecuador	1 × 1	Forest type	3	Square, rectangular	Forest type	–	2009–2013	2016–2019	?
Japan	4 × 4	–	1	Circular	–	1	2009–2013	2014–	5
New Zealand	4 × 4 to 8 × 8	Forest type	1	Circular	–	1	2002–2007	2009–2014	10
Peru	8 × 8 to 34 × 34	Regions	1	Different shapes	Regions	1/5	–	2014–	5
Russia	–	Forests strata	3	Circular	–	1	–	2007–	?
South Korea	4 × 4	–	4	Circular	–	1	1996–2005	2006–	10
US	2400 ha systematic hexagonal tessellation	–	4	Circular	–	1	2009–2013	2014–2018	5

?It is expected but still without specifying
–No associated information reported in the Country report

countries use a mixture of square and rectangular plots as well as transects depending upon the forest type (e.g. mountain or lowland tropical forest) and the variables measured (deadwood, litter, etc.). Accordingly, the forest area represented by each type of plot is variable. Additionally, because of the greater expenses associated with measuring field plots in remote and inaccessible forests, some countries such as Canada based part of their NFIs on aerial photographs.

Some of the analysed countries (Ecuador, Brazil, Peru) represent novel or emerging NFIs which have designed their NFIs to support national policy and decision making as well as to facilitate reporting to international conventions and processes such as the UNFCCC and Kyoto reporting. Thus, NFIs in these countries include methods for collecting data for reporting carbon stored in the different carbon pools. Furthermore, most of these emerging NFIs used remote sensing in combination with field data to improve estimates of the extent of forest, land uses, area cover change and to support the preliminary stratification process (McRoberts et al. 2010).

Finally, an important divergence found among the NFIs analysed in this chapter is that in some countries such as Argentina, different inventories are used for native and productive forests. This aspect may have important implications for attempts to assess the forest available for wood supply at national scale.

5.3 Analysis of National Definitions, Monitoring and Assessment from Non-COST Member Countries

Based on the raw information provided by the questionnaires and country reports for countries participating in the COST Action Usewood regarding Forest Available for Wood Supply (FAWS), quality of wood, increment, fellings, and mortality, Other Wooded Land (OWL) and Trees Outside Forest (TOF), WG1 formulates recommendations for statistical sound data collection and wood resource estimation. For this purpose, understanding the differences among the definitions and assessments used by NFIs at national levels is essential for development of reference definitions.

As Table 5.2 shows, the majority of countries analysed in this chapter neither have a FAWS national definition nor use the definition proposed by SoEF (FOREST EUROPE, UNECE and FAO 2011). Only Japan and New Zealand have national definitions (see Table 5.3), while in Canada there are different definitions at provincial administrative levels associated with different legal restrictions. Although most of the countries do not supply information corresponding to their FAWS national definitions and estimates, their FAWS definition is closer to "productive forest" interpretations discussed in Chap. 2. Furthermore, based on the related information available from geographical information systems (protected areas/ownership maps) or NFI field plots (e.g. distance to the road in Japan NFI), five countries could assess FAWS based on national/international definitions

(Table 5.2). In addition, the majority of countries associated, in one way or another, FAWS with the three main groups of restrictions (Environmental, economic and social) accounted in the proposed reference definition recommended by Alberdi et al. (2016).

However, these countries have such diverse forest management systems and unique forest conditions that setting thresholds for the restrictions considered in a FAWS definition is challenging (Fischer et al. 2016). Examples include the different tree or stand characteristics that regulate commercial logging or sustainable forest management such as age classes in Japan, tree diameters in Brazil, or harvesting intensity in Ecuador.

Table 5.2 Summary of NFI features from the non-COST member countries for purpose of defining and estimating FAWS

Country	FAWS		Restriction considered (Alberdi et al. 2016)		
	National (N)/ International (I) definition	Potential estimation	Environmental	Economic	Social
Argentina	–	–	–	–	–
Brazil	–	–	–	–	–
Canada[a]	?	–	x	x	x
Chile	–	–	x	x	x
China	–	–	x	x	x
Ecuador	–	x	x	x	x
Japan	N	x	x	x	x
New Zealand	N	x	–	x	–
Peru	–	x	x	x	x
Russia	–	–	–	–	–
South Korea	–	–	–	–	–
US	–	x	x	x	x

[a]Reported at provincial and regional level considering specific restrictions. Different definitions between state boundaries

–No associated information reported in the Country report

Table 5.3 National definitions of FAWS from the non-COST member countries

Japan	The forest available for wood supply can be considered as those forests which have reached cutting age and do not have any legal regulation
New Zealand	All areas included in the annual National Exotic Forest Description (NEFD) survey is productive forest planted for the purpose of timber harvesting and can be assumed to be technically and legally available

Regarding wood quality estimates, Table 5.4 shows that most of the countries record some specific stem quality variables such as dead/live state, health status (with biotic/abiotic damages), top diameter, minimum commercial diameter or height, stem curvature and forking. Only five countries assess quality classes in the field for the later quantification of assortments. Most of the analysed NFIs assess a large number of timber quality variables that could be used for developing a harmonised timber quality classification. However, they often apply different thresholds due to the uniqueness of their forests and their associated forest management procedures and industries. Consequently, although there is potential for developing harmonised estimation based on the common assessment of specific variables, considerable effort will be needed before the harmonised stem quality estimation can be realised (Bosela et al. 2015).

Forest change estimation is usually based on permanent plot field measurements at two consecutive points in time. In this regard, more than 70 % of NFIs used permanent sampling plots to estimate changes, while three other (Argentina, Peru and Canada, see Table 5.1) are not yet able to report statistical estimates of change because the first measurement cycle has yet to be completed. For permanent plots, the definitions of increment and drain rely on the distinguishing and grouping sample trees into change components such as survivor, ingrowth, ongrowth, removals and natural losses. However, only four of the analysed countries clearly specified their national definitions for increment or drain: China, New Zealand, US and Chile (see Table 5.5). For other cases, the change components vary depending on the sample tree selection method, management and unique commercial aspects of the country (see e.g. China). Compared with the two basic strategies used by European NFIs to estimate increment and drain (see Chap. 2), New Zealand, US and Chile seem to be closer to the least conservative of the two whereby components such as mortality trees, cuttings or ongrowth trees are taken into account.

Table 5.4 Summary of NFIs features from the non-COST member countries with respect to wood quality assessment

Country	Stem quality parameters	Classification system	Assortment estimation
Argentina	–	–	–
Brazil	x	–	–
Canada	x	–	–
Chile	x	–	–
China	x	x	–
Ecuador	x	–	–
Japan	x	–	–
New Zealand	x	x	–
Peru	x	x	–
Russia	x	x	–
South Korea	x	–	–
US	x	–	–

–No associated information reported in the Country report

Table 5.5 National definitions of increment and drain from the non-COST member countries

Country	National definition of increment and drain
China	The increment estimated by the China's NFI is defined as the volume increment of survivor trees between two field assessment periods plus the volume of ingrowth trees that exceed the dbh-threshold of 5.0 cm between the two points in time The drain estimated by the China's NFI is defined as the volume of trees that were found to be harvested between two field assessment periods
Chile	The increment is defined as the volume of trees with dbh >8 cm over bark taken by bore extraction Drain is defined as the sum of cutting removals, household fuelwood consumption, natural losses and waste estimation
New Zealand	The drain estimates include natural mortality, thinning, pruning and the subsequent decay of deadwood and litter
US	The net annual growth of growing stock is the average annual net change in wood volume of trees with dbh ≥12.7 cm excluding losses from cutting (gross growth minus mortality) during the inter-survey period plus the total volume of trees entering in the diameter classes with dbh ≥12.7 cm through ingrowth minus the volume losses from natural causes The net annual removals of growing stock is the annual average wood volume of trees ≥12.7 cm dbh removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use during the inter-survey period, in addition to the volume in logging residues or mortality due to logging damage (harvest removals). This component of change also includes the volumes of growing-stock trees removed due to land use changes (other removals)

Finally, within the framework of international environmental commitments, it is increasingly important to be aware of tree resources for all land uses as well as forests such as OWL and areas with TOF. FAO (2012) defines OWL as "land with a canopy cover of 5–10 % of trees able to reach a height of 5 m in situ; or a canopy cover of more than 10 % when smaller trees, shrubs and bushes are included" while TOF "are trees and tree environments on land not defined as forest or other wooded land". Table 5.6 shows that five of the seven countries considering OWL as a land use classification meet the FAO (2012) definition, while two (Argentina and New Zealand) do not meet the threshold regarding canopy cover. However, while all the countries apply thresholds associated with area size, tree cover and height, only three apply width and one applies diameter at breast height (dbh). The absence of these two last components is a challenge for the harmonised and straightforward definition of OWL (see Chap. 3). Furthermore, three of the NFIs account for shrubs, trees or the combination in their definition of OWL, while one accounts for grassland with scarce biomass. No analysed country classified land with TOF or assessed its wood resources.

Although seven of the twelve countries can classify land as OWL, few are currently able to assess wood resources by field or other measurements in their NFIs. Most of the NFIs conduct their monitoring exclusively on lands with tree or

Table 5.6 Summary of the national thresholds and features applied for OWL national definition, FRA definition application and current or potential wood resources estimation by assessment if possible for consistency in the table from the non-COST member countries

Country	OWL							
	Area (ha)	Width (m)	Tree cover (%)	Tree height (m)	Tree dbh (cm)	Other attributes	FRA definition	Current (C)/ potential (P) assessment
Argentina	<10	–	<20	<7	–	–	–	–
Brazil	<0.5	–	<10	–	–	Shrubs	x	–
Canada	–	–	5–10	<5	–	Trees/Shrubs	x	–
Chile	–	–	–	–	–	–	–	–
China	–	–	5–10	<5	<50	Trees/Shrubs	x	C
Ecuador	–	–	–	–	–	–	–	–
Japan	–	–	–	–	–	–	–	–
New Zealand	<1	<30	<30	<5	–	Grassland with tree biomass	–	C
Peru[a]	<0.5	<20	<10	<2/5[a]	–	–	x	–
Russia	–	–	–	–	–	–	–	–
South Korea	<0.5	<20	<10	<5	–	–	x	–
US[b]	–	–	–	–	–	–	–	–

[a]The predominant vegetation is represented by woody trees with a minimum height of 2 m in its adult stage in the Costa and Sierra, and 5 m for the Amazon Forest

[b]The land use classes, OWL and land with TOF are not used in the US and are not assessed separately from other lands with tree cover. The class closest to OWL and land with TOF is Woodland which is defined as land with trees whose cover is in the range 5–10 %

–No associated information reported in the Country report

shrub cover defined or classified as forest. This constraint limits the assessment of wood resources for OWL and also for areas with TOF.

5.4 Towards a Global Assessment of Forest Resources

In 2000, FAO (2001) reported that few forest inventories provided basic and up-to-date forest data as required for national or international policy. At that time, few NFIs had repeated cycles, and many countries had only partial or no forest survey. This report highlighted the lack of national forest surveys, particularly in developing countries. However, today major improvements can be seen in forest inventory capacities at the global scale (FAO 2015). There have been important increases in the number of countries that have initiated or currently maintain institutionalised forest inventory systems. For example, the total tropical forest area that is monitored with good to very good forest inventory capacities increased from

38 % (785 million ha) in 2005 to 66 % (1350 million ha) in 2015 (Romjin et al. 2015). Moreover, as this chapter show, most of the NFIs now rely on statistical sampling designs and have permanent plot networks. As a result of concern for issues such as acidification, biodiversity, climate change and forest sustainability, data for new variables are acquired with the resulting enrichment of forest survey data. Additionally, technological advances, particularly the widespread availability of remotely sensed data, have led to greater inventory efficiencies (McRoberts et al. 2010; Barrett et al. 2016). The combination of all these enhancements will further improve the accuracy and reliability of data and information on forest resources at the global scale. And, what's more, it will provide opportunities for all countries to participate in the global forest dialogue (Saket et al. 2010) where policies and decisions making in forest management are defined.

These international requirements and processes have promoted the concepts of open data and transparency (experiences, definitions and methodologies sharing). As some of the results of this book show, these raw data are necessary to construct robust reference definitions which are needed as the first step in the harmonisation process proposed by Vidal et al. (2008). For purposes of harmonised estimation of wood availability and use, new reference definitions for forest available for wood supply (Alberdi et al. 2016), wood quality (Bosela et al. 2015), changes (Gschwantner et al. 2016), OWL and TOF (Vidal et al. 2016) have been proposed in Chap. 3. These definitions were based on data obtained from country reports and questionnaires as well as from collaborative work in COST Action Usewood. Chapter 4 presents examples of bridges between the national and the reference definitions constructed for the harmonised estimation of wood availability and use. However, the diversity of specific national parameters and thresholds that characterise forest management systems and the unique forest conditions for the participating countries means that considerable efforts will be necessary before the harmonised estimations of the target attributes can be realised.

Although much remains to be done, we are closer than ever to obtain harmonised estimation of global wood resources. These improvements are the result of capacity building programs such as those by FAO-FRA and NFMA, ENFIN, COST Actions E43 and Usewood initiatives and the very large investment by governments to meet international forest report requirements (FAO 2015). These results support the importance of multilateral cooperation, international partnerships, and experience sharing.

References

Alberdi I, Cañellas I, Condes S (2014) A long-scale biodiversity monitoring methodology for Spanish national forest inventory. Application to Álava region. For Syst 23(1):93–110

Alberdi I, Michalak R, Fischer C, Gasparini P, Brändli U, Tomter S, Kuliešis A, Snorrason A, Redmond J, Hernández L, Lanz A, Vidondo B, Stoyanov N, Stoyanova M, Vestman M, Barreiro S, Marin G, Cañellas I, Vidal C (2016) Towards harmonized assessment of European forest availability for wood supply in Europe. For Policy Econ 70:20–29

Barrett F, McRoberts RE, Tomppo E, Cienciala E, Waser LT (2016) A questionnaire-based review of the operational use of remotely sensed data by national forest inventories. Remote Sens Environ 174:279–289

Bosela M, Redmond J, Kučera M, Marin G, Adolt R, Gschwantner T, Fischer C (2015) Stem quality assessment in European national forest inventories: an opportunity for harmonised reporting? Annals of For Sci 1–14

Cienciala E, Tomppo E, Snorrason A, Broadmeadow M, Colin A, Dunger K et al (2008) Preparing emission reporting from forests: use of national forest inventories in European countries. Silva Fenn 42:7388

CBD (2009) The convention on biological diversity. http://www.cbd.int/. Accessed 12 April 2016

Corona P, Chirici G, McRoberts RE, Winter S, Barbati A (2011) Contribution of large-scale forest inventories to biodiversity assessment and monitoring. For Ecol Manage 262(11):2061–2069

COST Action E43 (2010) Harmonisation of national forest inventories in Europe: techniques for common reporting. https://metla.fi/eu/COST/e43/. Accessed 12 Apr 2016

COST Action Usewood (2014) Improving data and information on the potential supply of wood resources—A European approach from multisource national forest inventories. https://sites.google.com/site/COSTactionfp1001/. Accessed 12 Apr 2016

FAO (1995) Forest resources assessment 1990—global synthesis. FAO Forestry Paper No. 124. Rome

FAO (2001) Global forest resources assessment 2000. Main report. Food and agriculture organization of the United Nations (FAO)

FAO (2012) FRA 2015 terms and definitions. Food and Agriculture Organization of the United Nations (FAO). Forest Resources Assessment Programme. Working Paper 180, Rome

FAO (2014) Food and Agriculture Organization of the United Nations. COFO/2014/6.3 Voluntary Guidelines on National Forest Monitoring. Twenty second session Committee on Forestry. Rome, Italy, p 23–27 June 2014. http://www.fao.org/3/a-mk174e.pdf Accessed 12 April 2016

FAO (2015) Food and Agriculture Organization of the United Nations. Global forest resources assessment 2015: Main report. How are the world's forests changing? www.fao.org/forestry/fra Accessed 12 April 2016

FAO (2016) Food and Agriculture Organization of the United Nations. Support on National Forest Monitoring. Moving forward: Selected achievements of the FAO Forestry programme in 2014–2015. In press. Rome, Italy

Fischer C, Gasparini P, Nylander M, Redmond J, Hernandez L, Brändli UB, Pastor A, Rizzo M, Alberdi I (2016) Joining criteria for harmonizing european forest available for wood supply estimates: case studies from national forest inventories. Forests 7(5):104

FOREST EUROPE, UNECE and FAO (2011) State of Europe's Forests 2011. Europe's Status & Trends in Sustainable Forest Management in Europe. FOREST EUROPE Liaison Unit Oslo; United Nations Economic Commission for Europe; Food and Agriculture Organization of the United Nations

Gschwantner T, Lanz A, Vidal C, Bosela M, Di Cosmo L, Fridman J, Schadauer K (2016) Comparison of methods used in European National Forest Inventories for the estimation of volume increment: towards harmonisation. Ann For Sci 1–15

Holmgren P, Persson R (2003) Evolution and prospects of global forest assessments. UNASYLVA-FAO 3–9

IPCC (2007) Climate change. The physical science basis. In AGU fall meeting abstracts (1:1)

Lanly JP (1982) Tropical forest resources (No. FAO FP-30). FAO, Roma (Italia) United Nations Environment Programme, Nairobi (Kenia)

Lawrence M, McRoberts RE, Tomppo E, Gschwantner T, Gabler K (2010) Comparisons of national forest inventories. In: National forest inventories: pathways to common reporting. Springer, The Netherlands, pp 19–32

MacDicken KG (2015) Global Forest Resources Assessment 2015: What, why and how? For Ecol Manag 352:3–8

McRoberts RE, Wendt DG, Nelson MD, Hansen MH (2002) Using a land cover classification based on satellite imagery to improve the precision of forest inventory area estimates. Remote Sens Enviro 81(1):36–44
McRoberts RE, Tomppo EO (2007) Remote sensing support for national forest inventories. Remote Sens Enviro 110(4):412–419
McRoberts RE, Tomppo EO, Naesset E (2010) Advances and emerging issues in national forest inventories. Scand J For Res 25(4):368–381
MEA (2005) Millennium Ecosystem Assessment. Ecosystem and human well-being: biodiversity synthesis. World Resources Institute, Washington D.C.
Morales-Hidalgo D, Kleinn C, Piazza M (2014) General principles to be taken in consideration in a national forest monitoring system. Paper presented at the 4th international scientific conference: problems of forest inventory and forest management planning, Organized by the Federal Forestry Agency (FFA), and the FSUE ``Roslesinforg' (Roslesinforg), Irkutsk, Russian Federation
Romijn E et al. (2015) Assessing change in national forest monitoring capacities of 99 tropical countries. Forest Ecol Manage 352:109–123
Saket M, Altrell D, Branthomme A, Vuorinen P (2002) FAO's approach to support national forest assessments for country capacity building. Forestry Department, FAO, Rome
Saket M, Branthomme A, Piazza M (2010) FAO NFMA—support to developing countries on national forest monitoring and assessment. In: Tomppo et al (eds) National forest inventories—pathways for common reporting. Springer, p 583–594
Ståhl G, Cienciala E, Chirici G, Lanz A, Vidal C, Winter S, McRoberts RE, Rondeux J, Schadauer K, Tomppo E (2012) Bridging national and reference definitions for harmonizing forest statistics. Forest Sci 58(3):214–223
Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories—Pathways for common reporting. Springer, p 612, ISBN 978-90-481-3232-4
UNFCCC (2009) United nations framework convention on climate change. http://unfccc.int/2860.php. Retrieved Feb 2015
Vidal C, Lanz A, Tomppo E, Schadauer K, Gschwantner T, di Cosmo L, Robert N (2008) Establishing forest inventory reference definitions for forest and growing stock: a study towards common reporting. Silva Fenn 42(2):247–266
Vidal C, Alberdi I, Redmond J, Vestman M, Lanz A, Schadauer K (2016) The role of European National Forest Inventories for international forestry reporting. Annals of For Sci 1–14