Erkki Tomppo
Thomas Gschwantner
Mark Lawrence
Ronald E. McRoberts
Editors

National Forest Inventories

Pathways for Common Reporting

Springer

COST

National Forest Inventories

Chapter 2
Belgium (Walloon Region)

Jacques Rondeux, Christine Sanchez, and Nicolas Latte

2.1 Development of the Regional Forest Inventory (RFI) in Wallonia

Belgium is organized as a federal state and forest inventories are the responsibility of the regions (Wallonia, Flanders and Brussels). Each region has developed its own inventory procedures more or less independently, although the first regional inventory launched by the Walloon region has provided the main elements in terms of sampling design and basic variables to be measured. Thus, strong similarities can be identified among the three regions which enable generally reliable estimates of the importance and the evolution of the Belgian forest over time.

Wallonia is the most wooded region, representing around 80% of the total Belgian forest. In 2004, it consisted of 544,800 ha, which corresponds to a woodland cover of 32.3%. Forests in Wallonia are characterized by very scattered ownership, great diversity of stand types, species compositions, sites and growing conditions.

The Walloon forest resources were enumerated from 1846 to 1980 using a national decennial census on agriculture and forests based only on land registry analyses. Very rough estimates of volume were made by the forest administration for public forests and by designated experts for forests in private ownerships. The approach was not very reliable for a variety of reasons: the objectives and variables were not well defined, the investigation methods were not homogeneous, there was a gap between the land registry statute and the field reality, and important delays occurred between data collection and the availability of first results for private forests. Further, statistical shortcomings resulted from using rough estimates and responses to questionnaires that were greatly influenced by the intentions and opinions of respondents.

J. Rondeux, C. Sanchez, and N. Latte
Unit of Forest and Nature Management, University of Liège (Gembloux Agro-Bio Tech), Belgium

E. Tomppo et al. (eds.), *National Forest Inventories*,
DOI 10.1007/978-90-481-3233-1_2,

Table 2.1 The forest inventory in Belgium (Walloon region)

Inventory	Years	Method	Number of plots
Census	1846–1980 (every 10 years)	General census based upon questionnaires, samples rules not clearly defined	No plots (land registry)
RFI1	1978–1981	Test survey samplings	~300
RFI2	1984–1988	Systematic sampling – Temporary plots – Variable-area circular plots (~15 trees)	~11,000
RFI3 (1)	1994	Systematic sampling – Permanent plots – Three fixed-area concentric circular plots	~11,000
	1994–2008	One-tenth plots measured each year	~1,100 per year
RFI3 (2)	1997	Additional plots radius 12 m (vegetation survey)	All the plots concerned
RFI3 (3)	1998	– Additional plots radius 36 m (forest functions, structure, damages, etc.) – Four satellites (regeneration micro-plots) – Deadwood variables (in one of the three plots comprising the mean diameter tree) – Use of electronic encoders	All the plots concerned
RFI-3 (4)	2000–2001	– Re-measurement after 5 years – Use of GPS	~2,200
RFI4	2008–2018	Start of the second cycle: Half of the plots re-measured after 5 years and the other half after 15 years	~1,100 per year

In 1978 new responsibilities were given to the regional entities including forest policy and management of natural and forest resources. As a result, the first attempt to use an inventory based on sampling methods (Table 2.1) was carried out during the period 1978–1981. Various tests were made to determine the feasibility of a quite new approach based on a sampling design that involved choosing the type and size of plots, the sampling intensity and the type of data to be collected. Between 1984 and 1988, a regional inventory was officially carried out by the University of Liège – Gembloux Agro-Bio Tech on a contractual basis. This inventory used temporary, variable-area circular plots installed on a systematic 1,000 × 500 m grid. The plot radius was selected so that the number of trees measured on each plot remained nearly constant (15 trees). The aim was to give a representative picture of the forest and its growing stock. Later, in response to the growing importance of sustainable management, the objectives assigned to the inventory were extended to biodiversity assessment and additional specific observations and measurements were introduced (Rondeux1999b).

Taking advantage of this first successful experience, a new inventory was formally set up in 1994 (Lecomte et al. 1994; Rondeux and Lecomte 2001). The methodology was modified to permanent sampling units consisting of three concentric circular plots for measuring growing stock; other plots for describing ground vegetation, the general structure of stands and forest health; and a cluster of four circular sub-plots for assessing natural regeneration.

A permanent forest resources inventory unit was created in 1996 as part of the regional "Nature and Forest Administration" with scientific supervision handled by the Unit of Forest and Nature Management of Gembloux Agricultural University.

After 1981, three initial goals were defined: (1) to undertake a statistical analysis of timber resources; (2) to meet specific requests from wood users, private and public owners, regional, national or international organisations, etc.; and (3) to provide the guidelines for developing and adjusting a regional forest policy by providing relevant, reliable and unbiased information.

As in other European countries, the inventory has grown in conjunction with the increasing demand of the major forest users and more societal requirements, especially the increasing demand for multifunctional forest data, development and monitoring of sustainable forest management.

2.1.1 Summary of the Major Events Regarding the Walloon Forest Inventory

1846–1980: General national census of agriculture and forest using different methods for private and public ownerships.
1980–1984: Preliminary tests of statistical methods
1984–1988: First regional forest inventory based upon a systematic sample with temporary, variable-area sampling units (RFI2) (1 plot/50 ha)
1994–2008: Permanent systematic forest inventory using three concentric sample plots and other plot sizes for vegetation and regeneration assessments
2008: Start of the second cycle with sampling units re-measured after 5 or 15 years using a predetermined scheme

2.2 The Use and Users of the Results

2.2.1 National Users

The users are above all the forest administration and forest authorities in charge of regional forest policy, scientific research (for very diverse research purposes needing spatial reference data) and various forest organizations. The data are also useful not only for administration levels (municipalities, public owners, etc.), nature conservation agencies and forest industries but also for assessing forest regulations and new silvicultural approaches.

Data are used for environmental decisions where special algorithms or supplementary calculations are necessary to satisfy increasingly sophisticated information requirements. If the first hesitating steps are far in the past, now special attention must be paid to avoid use of data for inappropriate purposes, particularly very specialised requests with objectives for which the type and the precision of the data collected are not appropriate.

The scope of the inventory is to provide data not only for estimating the current state of the forest but also for change and scenario analyses. Most information requirements concern data on land cover and land use, sustainable forestry, environmental monitoring (Koestel et al. 1999; Lecomte et al. 1999), carbon stocks evaluation, adequacy of species and site conditions in relation to global change, etc. In short, it is becoming a multi-resource inventory (Lund 1998; Rondeux and Lecomte 2005).

2.2.2 International Reporting

The RFI is continuously solicited for answering questions and providing data for international statistical reports. The RFI is the principal source of information for reporting to international organisations or conventions, such as FAO's and UNECE/FAO's Forest Resources Assessments procedure (TBFRA 2000, FRA 2005), the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests), Ministerial Conference on the Protection of Forests in Europe (MCPFE) and OECD in the frame of the Convention on Biological Diversity (CBD). It is used to produce information on forest health, biodiversity and carbon pools for the Land Use, Land-Use Change and Forestry (LULUCF) reports of the United Nations Framework Convention on Climate Change (UNFCCC).

There is also a strong relation between the Walloon RFI and the Great-Duchy of Luxembourg NFI. Indeed, the University of Liège – Gembloux Agro-Bio Tech is deeply involved in the implementation of the inventory and in providing results under the supervision of the forest administration of Great-Duchy of Luxembourg.

2.2.3 The Increasing Role of RFI in Assessing Biodiversity

Since 1994, the RFI has been an efficient tool for responding to the increasing demand for regional biodiversity assessments. Biodiversity is described through four key components in the RFI: ground vegetation, deadwood, forest edges and stand structure. Issues from the Helsinki and Lisbon ministerial conferences on the protection of forests (MCPFE 1996) have been taken into account to collect data for calculating indicators dealing with biodiversity, soil and water protection, forest vitality, health status, etc. The main variables and characteristics collected or calculated are:

- *Listings* (*relevés*) of all types of vascular plants in each specific vegetation plot (carried out in a 12 m radius plot, each plant is characterized by a coefficient composed of two digits: the first concerns abundance-dominance and the second sociability-dispersion). The data collected provide useful information for Natura 2000 site monitoring diagnosis. Biotopes are briefly described on the basis of key variables of habitats elaborated at the regional level. These observations were introduced for all plots since 1997.
- *The volume of deadwood* snags, fallen logs (stem parts) and branches, standing logs comprising (or not) branches and logging residues; fallen logs of at least 1 m length and 20 cm circumference are considered. Standing deadwood is measured according to the same rules applied to living standing trees. Lying deadwood is assessed in one of the three main plots depending on the mean circumference of standing living trees. Species category and stage of decay are also recorded. These measurements have been carried out for all plots since 1998.
- *The transition zone* between forest and open areas (edge) is described in terms of structural elements, density, specific composition and presence of particular habitats (deadwood, veteran trees, etc). A forest edge is considered every time the centre of a sampling unit falls in productive forest and for which the 18 m radius plot overlaps an open area (meadow, clear cut, road, etc.).

Other information on biodiversity assessment can be found in Rondeux (1999b), Rondeux and Sanchez (2009) and Sanchez et al. (2007). RFI data are sometimes used to describe natural and semi-natural biotopes, regardless of their state of naturalness, ecological value and their potential versus actual management. Carbon stock is evaluated from total volume per hectare (volume comprising stem and branches to an upper limit of 22 cm circumference). In the first step, green cubic volume is converted to dry weight (biomass) using factors (UNECE/FAO 1985) that vary from 0.35 to 0.50 according to the different components: species, wood under bark, over bark, other non wood aerial biomass, stumps and roots. In the second step, carbon stock is estimated by multiplying the dry weight of the biomass by a factor fixed at 0.45. Carbon amounts are estimated both for trees above ground and stumps as well as for roots (estimated to be roughly equal to total aerial volume $\times$ 0.20 $\times$ 0.50 for broadleaved trees or 0.40 $\times$ 0.45 for conifers) (Husch et al. 2003).

2.2.4 Other Outcomes of the RFI

Since its beginning, the inventory data has increasingly been used in fields other than those already described. Particularly meaningful and useful applications include important storm damage evaluations in 1990 and the study of the adequacy between soils and species (in relation to global changes). Genetic improvement has also been enhanced by analyzing stands exhibiting significantly different levels of productivity (top height at a reference age) on similar soil and environmental conditions. In addition, plot remeasurement data is used to address the component of forest management sustainability dealing with the balance between harvesting and growth rates.

More recently, the RFI has played a central role in giving a general overview of forest conditions (silviculture, growing stock, biodiversity's status, etc.) in the frame of a regional forest certification process.

Since its implementation, RFI data has also been very useful for additional applications: game damage assessment (Lecomte et al. 1992; Rondeux and Lecomte 1997a), beech disease evaluations (Rondeux et al. 2002), soil fertility assessments, Kyoto reporting at the national level, biodiversity quality assessments and Natura 2000 site delineation and classification.

In the future, the web site related to the RFI will include general results on forest evolution (areas, growing stock, biodiversity, etc.).

2.3 Current Estimates

The basic area estimates are given in Table 2.2a and basic volume estimates in Table 2.2b. RFI definitions are briefly given in the tables as well. The typology of the inventoried areas – or forest – is defined as follows and partially drawn from UNECE/FAO (1997) recommendations: wooded land managed for forest objectives comprising at least 0.1 ha in extent and including trees with a forest canopy of at least 10% (with a minimum height of trees of 5 m at maturity). Different elements are also part of the forest area such as: tree alignments, mud, moors, roads, open areas, clear cuttings, shrub-lands, plantations and wooded zones in which the trees are less than 5 m height and crown cover less than 10% (Lecomte et al. 1997).

Table 2.2a Basic area estimates from years 1996–2004

Quantity	Estimate (1,000 ha)	Percent	Associated definition	SE[a] (%)
Total region area	1,686.6	100		
Forest land	544.8	32.3	10% crown cover with minimum height of trees of 5 m at least 0.10 ha	0.15
RFI coverage			All land including forest (so named in land use)	
Productive forest land	477.8	28.3	Comprising growing stock	0.50
With trees measured	384.5	22.8		
Non-productive forest land	67.0	4.0	Roads, mud, moors, pools, clear cuttings	1.75

[a]Standard error.

Table 2.2b Basic volume estimates from the years 1996–2004

Quantity	Estimate	Description	SE[a]
Volume of growing stock (productive forest) (million cubic metre)	109.2	Stem volume to an upper circumference limit of 22 cm	2.21%
Volume of growing stock per hectare (productive forest) (m^3/ha)	228.4		n.a
Annual increment (productive forest) (million cubic metre per year)			n.a.
– Broadleaved stands	1.162		
– Conifers stands	2.567		
Annual increment per hectare (productive forest) (m^3/ha per year)			n.a.
– Broadleaved stands	5.111		
– Conifers stands	16.32		
Volume of deadwood (productive forest) (million cubic metre)		For lying dead wood	n.a.
– Standing	1.477	Minimum length 1 m	
– Lying	2.231	Minimum circumference 20 cm	

[a]Standard error.

2.4 Sampling Design

The ongoing inventory is a single-phase, non-stratified inventory using a systematic sampling design with plots at the intersections of a 1,000 m (east-west) × 500 m (north-south) grid. Points falling outside the forest are also taken into account in order to identify the land use and to evaluate changes in forest area over time.

Approximately 11,000 permanent sample plots have been established in forest areas. Remote sensing techniques are only used as complementary sources of information (maps, administrative documents, etc.) before visiting the sample points and more frequently in order to qualify a point as inside or outside the forest area.

One-tenth of the 11,000 permanent sampling units are remeasured each year according to a predefined scheme. The ground sampling intensity of 0.2% is one of the greatest in Europe. Sample plots to be remeasured are uniformly distributed throughout the territory so that annual forest resource estimates for the entire region can be obtained on the basis of measurements of 10% of the plots.

More recently, a new sampling design has been proposed according to a predefined scheme ensuring that the whole territory is uniformly covered. When the system has been completely implemented (RFI-4, Table 2.1), 50% of the visited plots per year will be re-measured after 5 years (increment calculation period) while the other 50% will be measured after 15 years (playing, to some extent, the role of temporary plots). When this procedure will be achieved, those plots re-measured on a 5-year-cycle or on a 15-year-cycle are revisited respectively 15 years or 5 years later. For a given point there is thus an alternation of intervals (short period becoming long and vice versa).

2.4.1 Sample Plots

In the inventory design, each sampling unit consists of concentric circular plots. (Fig. 2.1) comprising:

- Three main circular concentric plots with radii of 18, 9 and 4.5 m; on these three concentric plots tree circumferences (C) of living trees are measured as follows: trees with $C \geq 120$ cm are measured on the concentric plot with radius 18 m; trees with $70\text{ cm} \leq C < 120$ cm are measured on the concentric plot with radius 9 m; trees with $20\text{ cm} \leq C < 70$ cm are measured on the concentric plot with radius 4.5 m.
- Standing dead trees are measured in the same way as living trees while lying deadwood is measured on the same plot on which standing trees of the same mean circumference would be measured.
- Near the plot centre general observations related to physical soil properties (texture, drainage, depth, etc.) are collected; and furthermore for 10% of the productive forest plots, 21 soil samplings are collected for qualitative and quantitative soil analysis such as pH, cation exchange capacity, etc. These 21 soils sampling points are located as follows: one near the plot centre, three on the axes N-S and E-W (every 3 m from 6 to 15 m) and two in the azimuths 45°, 135°, 225° and 315° at 6 and 15 m from the plot centre.

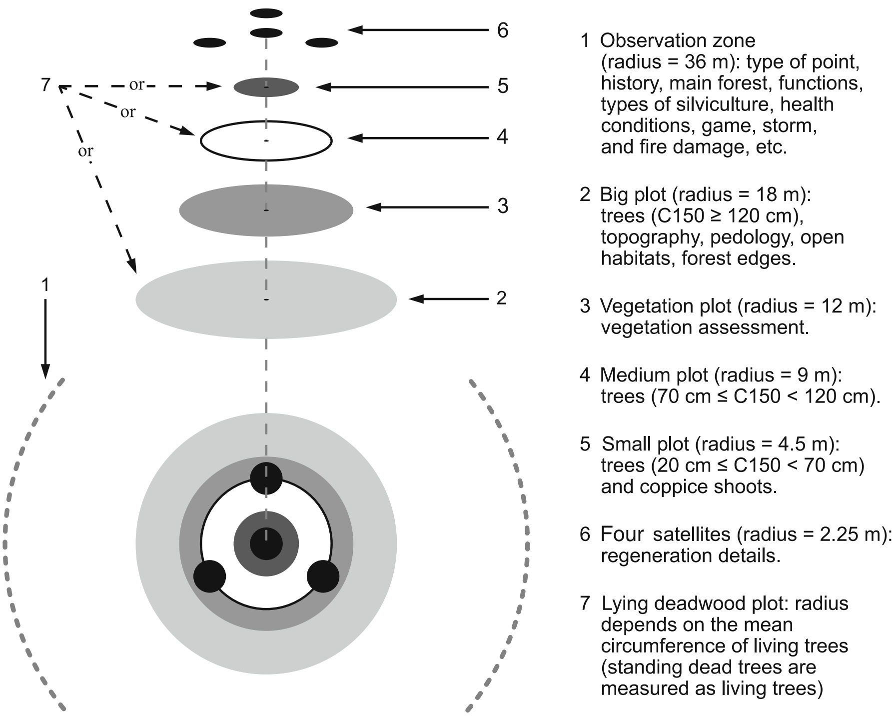

Fig. 2.1 General scheme of a sampling unit and nature of main data or information collected

- On the concentric circular plot with radius 18 m, in cases of edge, the intersection of the plot and the types of stands or land uses are measured and described before shifting the plot into the dominant type.
- One cluster of four circular sub-units especially set apart for regeneration measurements (radius of 2.25 m each), one of them being centred on the centre plot itself.
- One circular plot with radius 12 m used to describe all vascular plants (abundance, frequency, etc.).
- One circular area with radius 36 m (0.4 ha) for a visual diagnosis of health conditions, game, storm and fire damage, the general quality appraisal of trees, the main forest functions, the types of silviculture, etc.

2.4.2 Field Measurements

Since 1998, portable data recorders (HUSKY until 2005 and Panasonic tablet PC currently) have been used with dedicated software. Field measurements are divided into stand level data and tree level data. Stand level data are assigned to the following main thematic groups:

- General data and administrative information such as ownership, administration level, date, and crew identification;
- Plot identification data including plot number, coordinates, administrative references;
- Stand variables including tree species, structure, age, stage of development, silviculture;
- Site data including land use class, topography (altitude, slope, exposure), soil characteristics and ground vegetation (see Section 2.3)

At the tree level, the measured variables include circumference at 1.5 m above ground for standing living and dead trees, origin and length of lying deadwood, age of softwood, etc. Standing trees are measured when circumference at 1.5 m is at least 20 cm. Measurement of circumference at 1.5 m is the common rule in Wallonia, so conversion equations must be used to convert circumference at 1.5 m to diameter at 1.3 m. For both artificial and natural regeneration, the assessment of seedlings is only done by height classes. Other attributes gathered in the field include forest management intensity, damages and diseases (syndrome, time and intensity), microhabitats, natural hazards, tourist-recreational activities, infrastructures linked to forest activities or functions.

2.4.3 Management, Personnel and Equipment

The RFI is managed by the Walloon forest administration (General Directory of the Natural Resources and of the Environment, Division of Nature and Forests) and more precisely by a team consisting of one engineer and three technicians who are responsible for all the field measurements and operations dealing with data processing. The crew receives scientific support based on an agreement between the Regional Ministry of Agriculture and Gembloux Agro-Bio Tech. Scientific support work is done by an engineer and a computer scientist on renewable 1-year contracts. Cooperation with other scientific institutions also exists (e.g., for soil and ground vegetation investigations).

Field equipment is mainly selected for measuring trees and includes instruments such as Vertex for height measurements, pocket-sized GPS for identifying plots centre or retrieving them over time, field computers for collecting, controlling and transferring data, borers for taking soil samples, etc.

A particular effort has been made since 1998 to use electronic field recorders to help organize field operations and to check the encoded data (Rondeux and Cavelier 2001). Data are directly encoded on a tablet PC and automated procedures are used to verify the coherence of registered data. After the data is transferred into the main Microsoft Access database, data for each sample plot are again verified by the inventory staff engineer. Finally, an automated verification procedure takes into account the calculated variables to verify the likelihood of the results.

In the office, only a small network of personal computers linked to various electronic devices are used. Currently, this seems to be the best solution because of its great flexibility.

2.5 Estimation Techniques and Data Processing

2.5.1 Areas

A variety of area estimates are used in the estimation of other variables such as stand types, species composition and growing stock. Areas are estimated using the dot grid method (Zöhrer 1978) in which a grid is placed over the area (map) for which an estimate of area is sought. The grid covers all wooded areas (green colour on maps associated to particular symbols) and consists of rectangular 0.04×0.02 m cells at the map scale of 1:25,000. All dots that fall within the forest area are counted and, at this scale, each dot represents $0.04 \times 0.02 \times 25{,}000^2 = 500{,}000\ \text{m}^2 = 50$ ha.

2.5.2 Volumes

Volume tables based on regression models (Dagnelie et al. 1999) are available for twelve species (nine for broadleaves and three for conifers). Various types of volume can be estimated using three types of "entries": (1) single-entry based on circumference (C) at 1.5 m (or at 1.3 m) above-ground, (2) double-entry based on circumference (C) and tree height (H), (3) single-entry based on circumference (C) of trees and fixed dominant height (HD) of the stand to which they relate (Rondeux 1999a). The mathematical form of the three types of models used can be expressed as: $V = f(C, C^2, C^3)$; $V = f(C, C^2, C^3, H, C^2.H)$ and $V = f(C, C^2, C^3, HD, C^2.HD)$. The stem volume of a tree corresponds to the volume of the stem wood over bark and above the stump level to the top of the tree. Other models are used to estimate the volume of branches, the thickness of the bark, the circumference (1.5 m) of a tree in relation to the circumference of the stump, etc.

Stem volumes of trees are given over bark and under bark, above ground level to different limits expressed in lengths or circumferences (more precisely percentage of the circumference at 1.5 m), volume of branches to an upper circumference limit of 22 cm. Taper curve models giving circumference at different heights can also be used to estimate any stem volume based upon any limit. Only models providing stem and branch volumes to the limit of 22 cm are currently used in the RFI. By adding the two volumes obtained from the specific models, the "total" volume of a tree can be estimated. Volumes of fine wood (branches with a circumference less than 22 cm) are estimated in percentages of the above-ground volumes if total volume estimates are needed. That is the case (not used until now because of lack of validation) for biomass and carbon stock estimation through indirect methods like conversion factors (Husch et al. 2003).

Volumes of standing and lying deadwood are estimated using volume models for standing trees or formulas (cylinder – Huber formula) for lying pieces of wood with a minimum circumference of 20 cm and a minimum length of 1 m.

2.5.3 Increment

Because permanent sample plots will be periodically re-measured at 5 or 15 year intervals, it is possible to evaluate the increment of the growing stock as well as the evolution of the forest (areas, types, structures, stages of development, species, biodiversity, vitality, etc.). Specific algorithms have been elaborated for taking into account "ingrowth", meaning that the sizes of the trees to be measured are selected based on the size of the concentric circular plots. The concentric circles on which trees are measured can change between two successive measurements depending on their growth.

Gross growth, including or excluding ingrowth, is estimated, and the increment of the trees that have died or have been cut between measurements are added to the increment for the survivors present at the beginning and at the end of the fixed measurement interval. All the details for estimating increment are given in Hebert et al. (2005). Volumes and basal areas are estimated by species, stand and forest types, site fertility classes, age classes (conifers) or stages of development (hardwoods). In the context of monitoring sustainable forest management, the removals/increment ratio is calculated using data for removed trees (thinnings, regeneration cuttings) every time increments are reported.

2.5.4 Error Estimation

For areas and volume (or basal area), estimates of standard errors are based on two methods. The first is based on area estimation by dot grid, and the second on sampling error for volume. A standard error that represents the sampling error (in %) is systematically estimated according to the Zöhrer method (Zöhrer 1978) taking into account the number of points counted and the general shape of the zones to be estimated. For the total forest area, the sampling error is 0.15% or 800 ha (at a 95% confidence interval, considering the number of counted points and the great variation in the ownerships, parcel sizes, and stand composition of the Walloon forest) (Rondeux 1991). In the second method, formulas for random sampling have been used. In the case of systematic sampling, as used in the RFI, due to the large distances between sampling units and consequently the low probability of correlation between observations of the variables, formulas for random sampling have been used. Thus, sampling errors for volumes, basal areas and number of trees can also be estimated.

2.5.5 Data Processing and Analysis

Data encoding is done on a hierarchical basis at three levels: the sampling unit, the tree species and the individual tree. Therefore, it is possible to answer very different questions for which the majority are only reliable at those levels. The processed data are grouped by sets corresponding to sampling units (stand types, stand densities); individuals (number of stems, basal areas, various volumes, biomass, carbon stock); and species (basal area percentage, mean and top circumferences, dominant heights, site quality). More than 40 tables are used: 20 concern initial or processed information, 14 are "dictionaries" and 10 are "working tables". Requests are formulated at sampling unit, species or tree levels and generally on "à la carte" deliverables. Results are presented in various formats including graphs, maps, and tables.

2.6 Options for Estimates Based on Reference Definitions

Table 2.3 presents a brief summary of the status of harmonisation in the RFI. The estimates for all parameters can be obtained from the RFI except "deadwood volume by decay stage classes". Indeed, the national definition of deadwood

Table 2.4 The availability of estimates based on national definitions (ND) and reference definitions (RD)

Quantity	ND	RF	Responsible	Remark
Forest area	Yes	Yes	RFI	ND (0.1 ha) ≠ RF
Growing stock volume	Yes	Yes	RFI	ND = RF
Above-ground biomass	Yes	Yes	RFI	ND = RF
Below-ground biomass	Yes	Yes	RFI	ND = RF
Deadwood volume (=$DW_{10\ cm}$)	Yes	Yes	RFI	ND (6.4 cm) ≠ RF bridging function
Deadwood volume by decay stage classes	Yes	No	RFI	ND (three classes) ≠ RF
Afforestation Deforestation Reforestation (Kyoto 3.3)	Yes	Yes	RFI	ND = RF
Forest type	Yes	Yes	RFI	ND (regional vegetal associations) ≠ RF Label to Label

considers three classes instead of the four considered by the COST Action E43 reference definition. Note that circumference at 1.5 m above the ground level is used instead of diameter at 1.3 m to define the size of a tree.

The RFI and the Gembloux Agro-Bio Tech are working very closely to adapt definitions when necessary.

2.7 Current and Future Prospects

Some attempts are made to construct digital maps instead of simply adding qualitative and quantitative information to existing maps for each grid sample point (Rondeux and Lecomte 1997b) obtained from high resolution aerial photographs. The digital maps enable studies of the usefulness of stratification (i.e. on a forest structure basis) and take advantage of combining inventory data and their spatial references. Such an approach will probably be very useful to save time, to produce new spatial information related to the forest area evolution and to continuously improve the methodology.

2.8 Cost Action E43 and Its Influence on RFI

When COST Action E43 was launched, the RFI was already organized generally taking into account international conventions and rules. However, the action has given a very good overview of the forest inventories in Europe and abroad. It has thus been possible to "situate" the RFI into this European context thanks to the numerous outputs of the Action (reference definitions, measurements protocols, type of collected variables, etc). As stated during the duration of the Action, most of methodological choices made since the beginning of the RFI appear to be reinforced.

The most important elements that have been brought to light during the COST Action E43 concern thresholds of measurements, integration of European forest types, the method used to assess deadwood and, to some extent, the size of the sample plots referring to the associated variables. In order to be in agreement with other European countries concerning the variables to be collected, COST Action E43 has contributed once again to recommend the use of diameter at breast height (*dbh* at 1.3 m) instead of circumference at 1.5 m, commonly used in Belgium. Nevertheless, it is likely that conversion tables will still be a topical question for a long time.

References

Dagnelie P, Palm R, Rondeux J, Thill A (1999) Tables de cubage des arbres et des peuplements forestiers. Tables of tree and forest stands. Gembloux, Les Presses agronomiques de Gembloux, 128 p (in French)

Hebert J, Bourland N, Rondeux J (2005) Estimation de l'accroissement et de la production forestière à l'aide de placettes permanentes concentriques. Estimation of growth and forest production with concentric permanent plots. Ann For Sci 62:229–236 (in French)

Husch B, Beers TW, Kershaw JA Jr (2003) Forest mensuration, 4th edn. Wiley, Hoboken, NJ, 443 p

Koestel G, Lecomte H, Rondeux J (1999) La gestion forestière durable en Région wallonne partie: apports de l'inventaire permanent. Sustainable forest management in the Walloon Region part one: contributions of the permanent inventory. 1 – Concepts généraux et étude de faisabilité. Silva Belgica 106:9–15 (in French)

Lecomte H, Hebert J, Rondeux J (1992) Estimation des dégâts de chablis à partir d'un inventaire forestier permanent. Estimation of wind damage from a permanent forest inventory. Annales de Gembloux 98:49–62 (in French)

Lecomte H, Hebert J, Rondeux J (1994) Comparaison de plusieurs types d'unités d'échantillonnage dans la perspective d'un inventaire forestier régional. Comparison of several types of sampling units with a regional forest inventory. For Chron 70:304–310 (in French)

Lecomte H, Hebert J, Rondeux J (1997) Country report for Belgium. In: Study on European Forestry Information and Communication Systems. Reports on forestry inventory and survey systems. Vol. 1. European Commission. Vol. 1. Luxembourg, 673 p

Lecomte H, Koestel G, Rondeux J (1999) La gestion forestière durable en Région wallonne: L'apport de l'inventaire permanent. Sustainable forest management in the Walloon Region: The contribution of the permanent inventory. 2 – Intégration des indicateurs à l'inventaire. Silva Belgica 106:7–14 (in French)

Lund HG (ed) (1998) IUFRO Guidelines for designing multipurpose resource inventories: a project of IUFRO Research group 4.02.02 Vienna: IUFRO World Series, Vol. 8, 216 p

MCPFE (1996) Ministerial conference on the protection of forests in Europe. Ministry of Agriculture, Rural Development and Fisheries, Lisbon, 62 p

Rondeux J (1991) Management of small woods in Belgium. Q J For 85:37–42

Rondeux J (1999a) La mesure des arbres et des peuplements forestiers. Gembloux, Les Presses agronomiques de Gembloux, 522 p

Rondeux J (1999b) Forest inventories and biodiversity. Unasylva 196:35–41

Rondeux J, Cavelier T (2001) Inventaire forestier régional et saisie électronique des données: une synergie prometteuse. Regional forest inventory and electronic data capture: a promising synergy. Rev For Fr 53:81–87 (in French)

Rondeux J, Lecomte (1997a) Les dégâts de cervidés en pessière wallonne. Une application ciblée de l'inventaire forestier régional. Deer damage in spruce of Walloon: A targeted application of the regional forest inventory. Forêt Wallonne, 31:99, 6–9 (in French)

Rondeux J, Lecomte H (1997b) Inventaire forestier régional et applications cartographiques. Regional forest inventory and mapping applications. Silva Belgica 104:7–17 (in French)

Rondeux J, Lecomte H (2001) L'inventaire forestier wallon. The forest inventory of Wallonia. Rev For Fr, LIII:263–267 (in French)

Rondeux J, Lecomte H (2005) L'inventaire permanent des ressources forestières: observatoire et base d'un tableau de bord de la forêt wallonne. The permanent inventory of forest resources of the Walloon region. Wallonie 83:61–67 (in French)

Rondeux J, Sanchez C (2009) Review of indicators and field methods for monitoring biodiversity within national forest inventories. Core variable: Deadwood. Environmental Monitoring and Assessment. DOI 10.1007/s10661-009-0917

Rondeux J, Bourland N, Huart O, Lecomte H (2002) Importance et dispersion de la maladie du hêtre en Région wallonne: Les premiers résultats d'un inventaire spécifique. Importance and spread of the disease of beech in the Walloon Region: Preliminary results of a specific inventory. Silva Belgica 109(3):22–30 (in French)

Sanchez C, Claessens H, Puissant T, Lecomte H, Rondeux J (2007) Vegetation diversity assessment in Southern Belgium's permanent forest inventory. CABI:208–223

UNECE/FAO (1985) The Forest Resources of the UNECE Region (Europe, the USSR, North America). United Nations, New York/Geneva

UNECE/FAO (1997) Temperate and boreal forest resources assessment 2000, terms and definitions. United Nations, New York/Geneva

Zöhrer F (1978) On the precision of dot grid estimates. Resources Inventory notes BLM 12, Denver, Colorado, USDI Bureau of Land management, 15 p