

Chapter 29

Grand Duchy of Luxembourg

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29.1 The National Forest Inventory of the Grand Duchy of Luxembourg

29.1.1 History and Objectives

In the context of the resolutions of the Ministerial Conference on the Protection of Forests in Europe (MCPFE) and to meet the sustainable forest management commitments, the Grand Duchy of Luxembourg decided to implement a permanent National Forest Inventory (NFI) in 1990.

At that time the country used a full census (for public forests only), primarily at the scale of forest compartments, to provide general information on the type of stands, structure and volume per hectare. Satellite imagery and digital maps were also used to provide area estimate for small forest areas and various thematic maps.

The general aim of the NFI is to report on the state and the evolution of forests as concerning: the wooded and non-wooded area, stand composition, growing stock, regeneration, forest health and biodiversity. The inventory is becoming an important source of information for reporting to international organisations and a very pertinent tool that is relevant to the national forest policy decision-making. It facilitates monitoring the extent to which the sustainable forest management has been applied in managed forests.

Field data collection for the first inventory cycle began in 1998. Detailed results, including methodological aspects, of this first inventory cycle were published in 2003 in a well-documented textbook entitled “La forêt luxembourgeoise en chiffres” (The Luxembourgish forest in figures).

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A second inventory cycle was launched in 2009 and the results were published in 2014. It was an update of the forest situation based on features and indicators relating to the whole territory in order to keep records of the sustainable management of national forest heritage.

Comparison between the data from the two cycles allowed, for the first time in Luxembourg, to identify major trends of forest evolution. It became possible to assess changes in areas and volume, both in public and private forests. Also to some extent the forest productivity could be evaluated. It was also possible to assess the impact and the sensitivity of measures applied for more than 150 years and aimed at promoting sustainable management of the forests of the Grand Duchy. In Table 29.1 the main features of the national forest inventory of the Grand Duchy of Luxembourg are described.

29.1.2 *Sampling Methods and Periodicity*

The inventory is based upon a single-phase, non-stratified sampling based on plots that are distributed, on a systematic basis, at the intersections of a rectangular

Table 29.1 Description of the national forest inventory of the Grand Duchy of Luxembourg

Features of the inventory	General description
Type	Permanent (10 years cycle), inventory
Scale	National
Objectives	Characterisation of forest zones which have been defined by the United Nations Economic Commission for Europe (UNECE) and the Food and Agriculture Organization of the United Nations (FAO). Identification of the non-forest areas (globally). Both private and public properties are concerned
Sampling technique	Simple systematic sampling (single phase non-stratified). Every sampling point is located at the intersections of 1000 (east-west) × 500 m (north-south) grid. One point is the “image” of 50 ha. The whole country is covered by about 5200 sample points
Sampling unit	The sampling unit consists of five concentric circular plots where the measurements are realised (radii of 2, 4.5, 9, 18 and 30 m)
Sampling rate	The sampling rate is 0.2 %. It is calculated on the basis of the size of the inventoried circular plot with 18 m radius (0.1 ha)
Measuring cycles: duration and intervals	Duration of a measuring cycle: 2–3 years Interval between two successive cycles: 10 years The first cycle started between 1998 and 2000 and the second cycle between 2009 and 2011
Aerial photographs and cartography	The photo-interpretation and national cartographic maps were applied to pre-classify the sampling points (e.g. forests, roads, open areas, etc.) and to support the organisation of the field operations (plot location, remote identification of forest types)

1000 × 500 m grid across the whole country. Nearly 1800 permanent plots were established during 1999–2001 and were remeasured during 2009–2011. One can consider that the estimates provided by the national forest inventory correspond to reference years 2000 and 2010. The sampling intensity is 0.2 %.

In the inventory each sample unit comprises different plots (Fig. 29.1) which sizes are adapted to the nature of the collected data. The main sampling unit consists of several concentric circular plots with radii varying from 2 to 30 m. All living and dead standing trees with diameters (d) of at least 7 cm are measured on the three main plots as follows:

- plot with radius of 18 m: trees with $d \geq 40$ cm
- plot with radius of 9 m: trees with $20 \text{ cm} \leq d < 40$ cm
- plot with radius of 4.5 m: trees with $7 \text{ cm} \leq d < 20$ cm.

Another plot of radius of 30 m is used to collect information dealing with stand structure, health conditions, main forest functions (water protection, recreation and biodiversity), sustainable management, storm and game damage. Furthermore special attention is paid to the presence of biotopes referring to the directive “Habitat” 92/43/CEE and also to wetlands, rocks, open areas.

In addition to this sample unit configuration, 4 small plots of radius of 1 m are also used; one plot has a radius of 2 m and the center of this plot is the plot center. One of them is established at the plot center and the others are located at distances of 5 m from plot center in the cardinal directions. They are used for measuring variables linked to regeneration including cover percentage and species

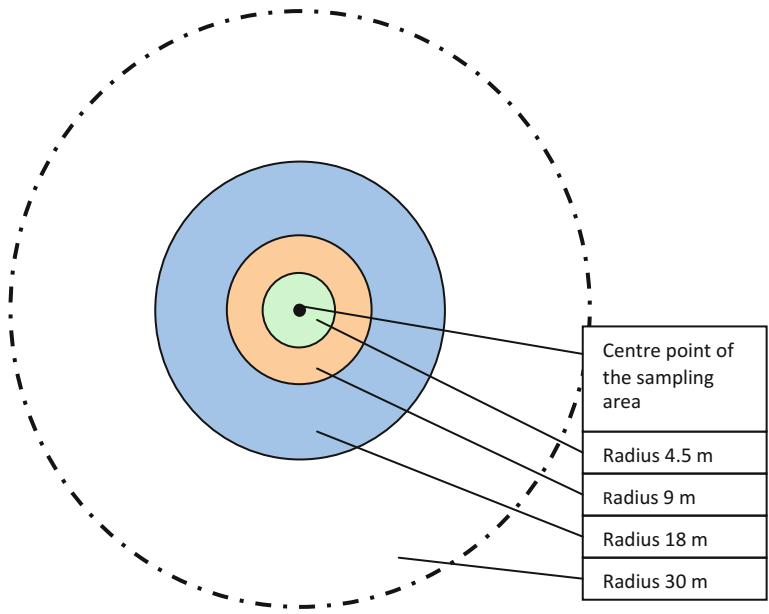


Fig. 29.1 Design of sampling area

composition for different stages of development. Saplings are defined as those trees with height >0.3 m and diameter at 1.3 m < 7 cm. The 9 m radius circle is used to measure lying dead trees (or pieces of wood) of at least 7 cm diameter and 1 m long. Edges and transition zones are observed along transects at the interception of the 18 m radius circle and the type of stands or type of land uses before shifting the plot into the dominant type (circle tangent to the intercept line).

29.1.3 Data Collection and Data Processing

The majority of data are collected in the field and, but for some parameters the data can be assessed from administrative and cartographic sources. The information assessed is divided in four categories:

- general data: administrative information, ownership type, plot location
- site variables: land use class, topography, soil characteristics
- stand variables: structure, age, stage of development, silviculture, health status
- tree variables: location, species, diameter at 1.3 m, total height.

An electronic recorder is used in the field so that a first quality control can be made. The encoded data are then transferred into the database to be checked again and processed through an automated verification procedure. Numerous parameters are computed using data which refer to sample units, tree species and individual trees.

For each tree basal area and volume to upper diameter to limit of 7 cm are estimated. Sample tree volume (stem and branches over bark) are calculated from volume equations based on regression models most commonly used in Belgium. Volume of standing and lying deadwoods are also estimated. Areas regarding to productive and non-productive forests are estimated through the dot grid method (1 sampling point falling in such areas corresponding to 50 ha).

Furthermore since 2012 growing stock increment and evolution of wooded areas are assessed from the comparison of the two successive inventories.

29.2 Land Use and Forest Resources

29.2.1 National Forest Area

The main information provided by the inventory concern the forest land area of the Grand Duchy. Conventionally forest land includes forests devoted to production, protection, conservation and multiple-use objectives. Forest land is defined as having a minimum area of 0.5 ha with tree crown cover of more than 10 %, comprising trees able to reach a minimum height of 5 m at maturity. In this respect

it should be noted that the forest area is remaining stable between 2000 and 2010 amounts to 91,400 ha which corresponds to a forest cover of more than 35 % (Table 29.2). This rate has not changed during the last ten years and is lower than the European average level but higher than in neighbouring countries: France (32 %), Germany (32 %) and Belgium (23 %).

29.2.1.1 Classification of Forest Stands

Luxembourgish forest is composed of about two-thirds deciduous forest and one-third coniferous forest (Table 29.3). Despite the high proportion of beech, oak and spruce forests which represent nearly 60 % of the stands, there is a significant presence of mixed stands (mixed beech-oak-hornbeam forests, other mixed deciduous forests, mixed forests with a dominance of conifers). This proportion shows a quite remarkable diversity of species at the national level in spite of the dominance of stands with a more homogenous composition.

29.2.1.2 Classification by Ownership Categories

Two types of forest owners can be distinguished: private owners and public owners. The latter include the state, municipalities, and public institutions (church councils, social insurances, companies where the state is a shareholder, etc.). The private forests are managed by private bodies and/or by private persons whereas the public

Table 29.2 Forest land classification

Forest land		Area in 2000 (ha)	Area in 2010 (ha)
"Forest"	Stands	85,750	85,300
	Clearcuts	650	850
	Forest roads	450	350
	Clearings (surface between 10 and 50 ares)	400	300
	Wetlands (surface between 10 and 50 ares)	250	200
	Feeding areas (surface between 10 and 50 ares)	(0)	(50)
	Bushes, shrubs (surface between 10 and 50 ares)	250	550
	Linear elements (roads, overhead power lines)	500	800
	Hydrologic elements	250	300
	Sub-total "forest"	88,500	88,700
"Other forest land"		1800	1700
"Groves of trees"		1150	1000
Total forest land area (ha)		91,450	91,400

Table 29.3 Species distribution in Luxembourg's forests and rate of change from 2000 to 2010

Type of stand	Area (ha)	Area (%)	Change in % (2000–2010)
Beech	18,350	21.3	-0.7
Oak	15,850	18.4	-1.1
Broad-leaved trees	1650	1.9	-1.0
Beech-oak-hornbeam mixed forests	12,700	14.7	+2.9
Other mixed deciduous forests	4800	5.6	-0.4
Mixed forests with a dominance of deciduous trees	2000	2.3	+0.8
Other deciduous trees	2700	3.1	+0.9
Total deciduous stands	58,050	67.3	+1.4
Spruce	16,200	18.8	-1.2
Pine	650	0.8	-0.4
Douglas fir	2650	3.1	+0.2
Larch	350	0.4	-0.1
Mixed coniferous	2000	2.3	-0.3
Mixed forests with a dominance of conifers	5050	5.9	+0.0
Other conifers	350	0.4	+0.1
Total coniferous stands	27,250	31.7	-1.7

forests that come under the Forestry Regime are managed by the Nature and Forest Administration (Administration de la Nature et des Forêts).

In spite of an increase of the proportion of the total area of public forests, the proportions of private and public owners of the Luxembourgish forest remain nearly the same, 54 % private and 46 % public (Table 29.4). The difference of these two types of ownership has been reduced at 7350 ha (8 % of the forest area) compared to 9350 ha in 2000 (10 % of the forest area).

The public forests are mainly composed of deciduous forest (80 %) whereas the private forests are divided in almost equal parts in deciduous forest (56 %) and coniferous forest (42 %) which mainly consists of spruce forest (68 %) (Table 29.5). This situation remains stable for the private owners in contrast to the

Table 29.4 Forest area by type of ownership

Type of ownership	Forest area (ha)	Area (%)	Area change (%)
Municipalities	30,900	33.8	+1.0
State	9950	10.9	+0.2
Public institutions	1150	1.3	0.0
Sub-total public forest	42,000	46.0	+1.2
Private	49,400	54.0	-1.2
Sub-total private forest	49,400	54.0	-1.2
Total	91,400	100.0	0.0

Table 29.5 Area by type of stand and type of ownership

Type of stand	Public forest			Private forest		
	Area (ha)	Area (%)	Area change (%)	Area (ha)	Area (%)	Area change (%)
Beech (<i>Fagus sylvatica</i>)	12,000	29.3	-0.2	6350	14.0	-1.5
Oak (<i>Quercus</i> spp.)	6600	16.2	-0.4	9250	20.4	-1.5
Broad-leaved trees	800	2.0	-0.8	850	1.9	-1.0
Beech-oak-hornbeam mixed forests	8900	21.8	+3.9	3800	8.4	+1.7
Other mixed deciduous forests	2350	5.8	-0.6	2450	5.4	-0.3
Mixed forests with a dominance of deciduous trees	850	2.1	+0.9	1150	2.5	+0.6
Other deciduous trees	1000	2.5	+0.6	1700	3.7	+1.2
Total deciduous stands	32,500	79.7	+3.4	25,550	56.3	-0.8
Spruce (<i>Picea</i> spp.)	3150	7.7	-0.7	13,050	28.8	-0.9
Pine (<i>Pinus</i> spp.)	400	1.0	-0.5	250	0.6	-0.3
Douglas fir (<i>Pseudotsuga menziesii</i>)	900	2.2	-0.1	1750	3.9	+0.4
Larch (<i>Larix</i> spp.)	200	0.5	-0.4	150	0.3	+0.1
Mixed coniferous forests	750	1.8	0.0	1250	2.8	-0.5
Mixed forests with a dominance of conifers	2700	6.6	-2.2	2350	5.2	+1.6
Other conifers	(50)	(0.1)	+0.1	300	0.6	+0.1
Total coniferous stands	8150	19.9	-3.8	19,100	42.2	+0.5

public forest where the gap between deciduous and coniferous is growing, especially due an increase of beech-oak-hornbeam mixed stands.

29.2.2 Wood Resources and Their Use

Wood production remains an important facet of Luxembourg's forest policy. In this context it is essential to characterise and quantify the timber resource in terms of species, structures and growing stock or even size categories. On one hand this allows the forest manager to better plan his silvicultural interventions and on the other hand the timber industry can evaluate the potential wood supply over the short and medium term. The evaluation of carbon stocks and the description of potential forest habitats for fauna and flora are other important outcomes of the use of such data.

The standing stock volume of stem wood over bark is about more than 31 million m³ (Table 29.6). The coniferous stands and especially the mixed

Table 29.6 Volume of heavy timber by structure and type of stand

Structure	Type of stand	Volume of heavy timber logs			Total volume of heavy timber		
		Average volume per hectare (m ³ /ha)	Change in the average volume per hectare (m ³ /ha)	Total volume (m ³)	Average volume per hectare (m ³ /ha)	Change in the average volume per hectare (m ³ /ha)	Total volume (m ³)
High forest	Beech	362	+35	6,629,000	443	+42	8,104,000
	Oak	300	+45	2,206,000	349	+51	2,566,000
	Broad-leaved trees	176	+69	291,000	191	+74	315,000
	Beech-oak-hornbeam mixed forests	355	+15	4,132,000	431	+20	5,020,000
	Other mixed deciduous forests	151	+28	612,000	169	+30	685,000
	Mixed forests with a dominance of deciduous trees + other deciduous trees	186	+52	696,000	199	+50	747,000
	Total deciduous high forests	312	+30	14,566,000	373	+34	17,437,000
	Spruce	442	+93	6,986,000	442	+93	6,990,000
	Douglas fir	379	+91	986,000	379	+91	986,000
	Pine and larch	352	+43	352,000	354	+43	354,000
Coppice	Mixed coniferous forests	513	+167	975,000	513	+167	975,000
	Mixed forests with a dominance of conifers + other conifers	318	+42	1,687,000	341	+44	1,809,000
Total of stands	Total coniferous high forests	413	+85	10,987,000	418	+86	11,114,000
		254	+46	2,607,000	264	+53	2,711,000
		337	+49	28,159,000	374	+54	31,262,000

coniferous forests are characterised by average volumes per hectare higher than those observed in the deciduous stands. Among the latter, other mixed deciduous forests represent the lowest volumes.

In terms of evolution over time the average volume per hectare of standing total heavy timber has increased during the period 2000–2010 as well as for the deciduous forests (+34 m³/ha, +11 %), the coniferous forests (+86 m³/ha, +26 %) and coppice (+53 m³/ha, +22 %). Heavy timber includes those stem and branches that have top diameter >7 cm in diameter.

The volume of firewood in high forests is significantly represented in the public forest: more than 80 m³/ha, thus 20 % of the volume of standing heavy timber. Only the half of this volume is found in private forest ownership, the majority of which are, covered by conifers. At stand level firewood reserves are highest in the deciduous forests, the mixed forests with a dominance of conifers and other coniferous forests. Beech forests and the beech-oak-hornbeam mixed forests supply firewood volumes which are quite higher than those generally found in other stands.

The annual volume increment of high forests amounts to 10 m³/ha/year or 758,000 m³/year (Table 29.7). The removals represent about 59 % of this increment. However, this national average is subject to local variations according to present species, age, forest site productivity, etc.

Table 29.7 Increment and removals of heavy timber by type of stand

Type of stand	Increment (m ³ /ha/year)		Removals (m ³ /ha/year)	
	Heavy timber logs	Total heavy timber	Heavy timber logs	Total heavy timber
Beech	5.8	7.7	3.9	4.8
Oak	5.1	6.2	2.9	3.4
Broad-leaved trees	6.2	6.8	1.2	1.3
Beech-oak-hornbeam mixed forests	5.7	7.4	4.2	5.2
Other mixed deciduous forests	5.0	5.8	2.3	2.6
Mixed forests with a dominance of deciduous trees + other deciduous trees	6.2	6.8	1.6	1.8
Total deciduous high forests	5.6	7.2	3.5	4.2
Spruce	16.2	16.3	10.4	10.4
Douglas fir	16.6	16.6	9.8	9.8
Pine and larch	9.6	9.8	4.2	4.2
Mixed coniferous forests	15.3	15.4	7.5	7.5
Mixed forests with a dominance of conifers + other conifers	9.0	9.8	4.3	4.6
Total coniferous high forests	14.5	14.7	8.6	8.7
Total of high forests	9.0	10.0	5.4	5.9