NATIONAL EXPERT-BASED ASSESSMENTS: BELGIUM

THE BELGIAN NARRATIVE ON FOREST RESTORATION

SUPERB
Upscaling Forest Restoration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036849.

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INTRODUCTION: FOREST MANAGEMENT IN FLANDERS VS. BELGIUM

This narrative focuses on forest restoration in Flanders, not for the whole of Belgium. This is because the authority on forest policy and management was moved to the Belgian Regions in the 1980s.

Federal state structure – authority of the regions

Originally, Belgium was a country with national centralised administrations and legislation (e.g., national forest law of 1845). A series of institutional reforms started in the 1970s, transforming the country into a federal state consisting of three regions (Brussels, Flanders and Wallonia; Figure 1). Since the second Special Law on Institutional Reforms (August 8, 1980), the regions are responsible for almost all issues dealing with the environment, including forests and nature conservation. Hence, this report will focus on the situation in Flanders, especially on the developments after 1990. Indeed, in this last period, separate legislation was developed for the different regions, and policy and management of forests clearly diverged over this last period, with more focus on productive function in Wallonia, and more on recreation and conservation functions in Flanders and the Brussels Capital Region.

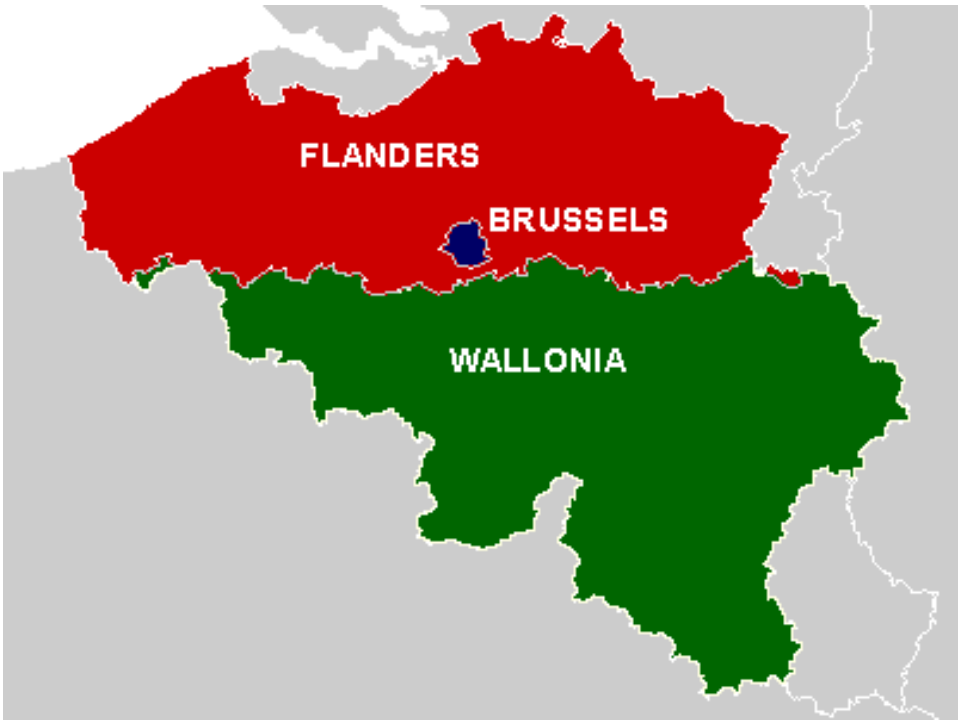

Figure 1. Belgium, with its three regions.

Deforestation in certain regions has resulted in the creation of wastelands, which are completely unproductive and ecologically degraded areas. Examples of wastelands include bare mountain ridges, slopes, drifting sands, inland dunes, and uncultivated heaths. By 1898, between 430,000 to 970,000 hectares of wasteland were identified, mostly in mountainous areas. Forest restoration initiatives have primarily focused on reclaiming these wastelands, particularly in the northern edge of the Alps, the drifting sand areas of the Marchfeld in the northeast of Vienna, the mountain wastelands in the Central Alps, and the karst areas in the southern peripheral Alps (Johann, 2001; Weigl, 2001b).

Forests in Belgium: differences between Flanders and Wallonia

Nowadays forest covers over 600,000 ha in Belgium and almost all forests are managed as high forest. As shown in Table 1, there is a clear difference between forests in Flanders and Wallonia.

In Flanders, forest covers only about 11% of the total area. Forests are often originating from plantations on former heathlands and wet grasslands: pine and poplar plantations make up almost half of the forest area, while only ⅓ of the forest area consists of broadleaved stands of indigenous species (oak (Quercus spp.), beech (Fagus sylvatica L.), mixed deciduous stands). Forests in Flanders are clearly part of an urbanized and industrialized region. In this context, forest goods and services are mainly related to socio-cultural and ecological services. This is comparable to regions like the Netherlands, Denmark and southern UK.

In Wallonia, with an average forest cover of over 30% (470,000 ha), forest is much more prominent. In the more rural regions of Wallonia, it plays an important role, also economically. Vast forested areas are found especially on the plateau of the Ardennes. Over ⅓ of the area consists of Norway spruce (Picea abies (L.) Karst.), (while it is marginal in Flanders due to inadequate climatic conditions). It was mainly planted on former low-productive oak coppice stands. Broadleaved high forest stands of indigenous species (oak, beech, mixed deciduous stands) make up about half of the forest area.

Policy and developments on forest restoration were quite similar in Flanders and Wallonia before the 1990s, with strong focus on reforestation of heath- and moorland and conversion of low productive coppice stands to high forest, in both cases introducing conifer plantations. In the more productive broadleaved forests, gradual conversion from coppice and coppice-with-standards to high forest was done in both parts of the country. From the 1940s to the 1980s, focus on both regions was on production of industrial timber and buildup of standing stock.

Table 1. Major forest stand types and extent in Flanders and Wallonia (after Waterinckx and Roelandt, 2001; Lecomte et al., 2003).

National forest types	Forest types for biodiversity assessment (FTBA, BEAR)	Flanders		Wallonia	
		Area (ha)	(%)	Area (ha)	(%)

Oak forests	Mixed oak and oak hornbeam forests	11,500	8%	84,800	18%
Beech forests	Lowland and sub-montane beech forest	5,000	4%	42,300	9%
Poplar plantations	Idem	25,000	17%	9,900	2%
Mixed deciduous forests	e.g. swamp, fen and flood plain forests	33,000	25%	113,300	24%
Total Broadleaves		*74,500*	*54%*	*250,300*	*52%*
Pine plantations	Idem	40,000	30%	20,000	3%
Spruce plantations	Idem	3,000	3%	172,400	36%
Douglas fir plantations	Other plantation		-	10,800	2%
Larch plantations	Other plantation		-	8,300	2%
Mixed coniferous forests	-	19,000	13%	20,700	4%
Total Coniferous		*62,000*	*46%*	*227,500*	*48%*
Total area		**136,500**[1]		**477,800**	

Policies and priorities started to diverge when authority was rendered to the regions in the 1980s. In Flanders, the main focus moved to the recreational and conservation function of forests, overarching the productive functions. In Wallonia also, the concept of multifunctionality became paramount, but the productive functions remained prominent. Recently, large areas of Norway spruce were ravaged by bark beetle attacks, with more than 1 million m³ of salvage logging. This has started the debate about conversion of conifer monocultures into more mixed and resilient climate-proof forests.

Flanders: A long history of low forest cover and intensive use

Flanders (Belgium) has been a densely populated area for many centuries. Forests were already cleared and exploited by humans in prehistoric times. As early as the first century BC, forest cover in the North-West European lowlands had gradually decreased to about 50% of the total land cover, followed by a slight recovery during the Dark Ages (4th–8th century AD) (Verhulst, 1995).

[1] This figure is the sum of surfaces covered by different tree species, based on the forest inventory (NFI); Total forest area, including forest roads, clearcut areas, etc. is about 14,000 ha (see below).

In the lowlands of the current area of Flanders, a steep decline of forest cover took place especially during the Full Middle Ages (12th–13th century AD). At that time, financial means, organisation and workforce were available for large-scale clearing of 'wilderness'. High population density created demographic pressure to convert woodland and wasteland to farmland and provided the required workforce to perform it. Means were available, as the region was at that time one of the wealthiest regions of the world, with powerful and rich landlords and cities. Organisation and facilities were provided by monasteries. Around 1250, less than 10% of forest cover in the ancient County of Flanders was left (Verhulst, 1995; Tack & Hermy, 1998). In the Duchy of Brabant, large-scale deforestation also took place, be it about 100 years later. Since that time, total forest remained rather constant, with a slight increase in the 18th century to about 12% (De Keersmaeker et al., 2001; 2014).

For centuries, these remaining forests were used very intensively to maximise the production of resources like firewood, utensils and construction wood (Tack et al., 1993; Tallier, 2004). Already as early as the 14th century, strict regulations and control on the harvest of wood and grazing of domestic cattle were imposed to prevent the depletion of the essential wood resource (Goblet d'Alviella, 1927; Tack et al., 1993; Vandekerkhove et al., 2016a; 2018). Most forests were managed as coppice systems focused on the production of firewood, utility wood and charcoal. In the larger estates of nobility and monasteries, coppice with standards as applied and high forest was exceptional (Tack et al., 1993; Tack and Hermy, 1998; Tallier, 2004).

Apart from economic goals, the larger forests were also important hunting grounds for their feudal owners. For this purpose, hunting reserves could be installed with different management, aimed at forests with large trees and limited undergrowth.

However, in these management systems, primarily, there was no place for late successional development stages and conservation of dead wood, large and old trees. Century-old user rights also gave local people the privilege to collect all dead and dying trees both in private and public forests (Tack et al., 1993; Tallier, 2004). Also, in periods of warfare and political instability, pillages disrupted management regimes, and lead to degradation of the forest.

Forest cover further decreased and reached a minimum of about 9% halfway through the 19th century. The first half of the 19th century was indeed characterised by further deforestation, due to forest clearings for agriculture. There was widespread famine and remaining forests lost most of their economic value due to the widespread introduction of fossil fuels (De Keersmaeker et al., 2014). Not only private forests were deforested: between 1815 and 1845, also several 10,000 ha of state forest were sold and for a major part deforested: forests were no longer considered of economic and strategic importance, as wood could be easily imported (Tallier et al., 2018).

Faced with further deforestation and degradation of the remaining forests, a first milestone was the publication of the Belgian Forest Code in 1854, aimed at halting the deforestation and degradation of forests. It was strongly inspired by the French Forest Code of 1827, that in its turn went back to the Code Colbert of 1669 (Tallier et al., 2018). Deforestation was strictly regulated from now on, and most of the public user rights (such as forest grazing) were abolished and forbidden.

By that time, the demand for industrial timber was strongly increasing. So, the state forest service was reinforced, and incentives were made to urge communities and private owners to reforest degraded forest areas and private and public 'wasteland'. These lands were excluded from taxes if they were newly afforested.

Between 1850 and the 1980s, this resulted in a slight increase of the forest cover, but this overall figure, however, conceals continuing deforestations (30–50% decrease on fertile silt loam deposits), mainly for agriculture and infrastructure, that were balanced by new afforestation areas, primarily on former heathlands and alluvial meadows, targeted at the delivery of industrial wood (De Keersmaeker et al., 2014).

In the 19th and 20th century, traditional management systems were replaced by high forest management and plantation forestry. Coppice forests were gradually converted to high forest or were cut and replaced by even-aged stands of beech and oak; in alluvial forests, poplars were planted. The new afforestation areas were plantations, mainly Scots pine (and later also larch and Corsican black pine) on the heathlands, and poplars on alluvial grasslands. These management systems were fully focused on wood production and excluded dead wood and large trees (Branquart et al., 2004). Large tree dimensions were economically not desired (no specific market, difficult to transport, risk of hidden defects like discoloration and rotten core) and forest management was tailored accordingly. The retention of dead wood was considered as a form of negligence, income loss or even bad management, as dead wood was considered a source of diseases. (De la Blanchère & Robert, 1889; Korpel', 1997; Nageleisen, 2005).

First initiatives on nature conservation/restoration and forests

First ideas on nature conservation and rewilding date back to the second half of the 19th century, when several conservation initiatives were taking place at both sides of the Atlantic, with the creation of the first National Parks in the US (Yellowstone, Yosemite), and conservation of the remnants of primary forests in Central Europe (e.g., Rothwald, Bubinski Prales).

In Belgium and Flanders, the first initiatives date back to the beginning of the 20th century. In 1902, Charles Bommer, head of department of the Botanical Garden, published a brief report on the creation of nature reserves in Belgium for the newly installed Commission for Conservation of Nature at the forest administration. In this document, he pleaded for the installation of strictly unmanaged reserves in several moorland and forest areas. For whatever reason, the idea was not further developed and ten years later, Massart (1912a), in his standard work on nature conservation in Belgium, repeated the need for a set of unmanaged nature reserves, suggesting specific sites like the Sonian Forest. Shortly after, World War I halted the animosity towards nature conservation, not to be resumed after the war (Hoste et al., 2016).

During World War I, several forests were devastated, both by shelling in the front line, but also further away forests were stripped and ransacked by the occupying German troops, who transported the wood both to the frontline and the homeland.

During the interbellum, focus was on the reconstruction of the country, including the devastated forests. A large-scale forest restoration programme was performed. Several thousands of ha were replanted, with labour and young trees provided and financed by the defeated party (see below).

On protection, very little was done. Mosseray (1938) published an opinion paper in the Belgian Journal of Botany, pleading again to set up a network of nature reserves, and to exclude them from the 'devastating disturbance of man'. His plea, however, was not endorsed, and smothered by the dawn of World War II.

After World War II, first initiatives for nature protection in Belgium were focused on the conservation of moorlands (Hautes Fagnes in 1957), coastal dunes and estuaries (Westhoek and Zwin in 1957 and 1951), or heathlands (Mechelse and Kalmthoutse Heide in 1967; 1968), lakes and swamps (De Zegge and Snepkensvijver in 1953). It was only in the Law on Nature Protection (1973) that also forests came into the picture, with the possibility of forest reserves legally inscribed, but no initiatives were taken.

Forest management and policy remained focused on avoiding further deforestation, and management was focusing on wood production, primarily through even-aged stands, producing uniform forest products. Mixed stands were the exception; variation was achieved at larger scale by combining monospecific stands of different age or species

Awareness for conservation and restoration aspects in forests only became apparent from the 1980s onwards. Forest education at university was strongly influenced by Central European principles of close-to-nature forestry (Swiss forestry school of Leibundgut). Forestry academics (Dua, 1975; Van Miegroet, 1977; Lust, 1982) were the first to advocate the principles of multifunctional, close-to-nature forestry, where natural values and nature conservation are considered evenly important as the productive and recreational function of forests, and stressed the necessity to develop mixed, natural forests and a network of set-aside areas.

A different mindset

It was mainly due to problems of forest health (acid rain, Waldsterben) and important changes in wood market (collapse of the demand for pine wood due to closing of the mining industry) that the focus of forestry moved to diversification and close-to-nature management in mixed stands. The idea of multifunctionality and the importance of dead wood and aspects of nature conservation became increasingly incorporated in mainstream forest management.

Much more than the Habitat Directive of 1992, the new Flemish Forest Decree of 1990 had a strong impact on forest management, conservation and restoration. This progressive new forest law focused on multifunctional forest management, both in public and private forests and states that productive, ecological and recreational functions are equally important. Subsidies and stimuli are put in place to work towards mixed forests and indigenous species and to open private forests to public access.

The Nature Conservation Decree of 1997 also had an important impact on forest management and nature conservation and restoration in forests, as it also provides, for the first time, a number

of specific 'principles' of conservation that are to be applied also beyond strictly protected areas. These principles proved to be very influential, especially on aspects of integrative nature conservation in forest practice.

Two basic principles are to be applied in all areas of conservation concern, including all forests:

- stand-still-principle: management operations (including forest operations) should not deteriorate the natural value of a site. This was implemented in forest policy: no mixed forest can be transformed to monoculture, no indigenous species replaced by exotics, or broadleaves by conifers.
- precautionary principle: all management operations (including forest operations) should be evaluated for their impact on natural values; avoidable important damage is to be excluded.

Several legal instruments regulating forest management have been issued since, to practically implement these ambitious principles, e.g., the guidelines on felling permits and Criteria for Sustainable Forest Management (CSFM).

They gave a strong impulse to the integration of nature conservation in managed forests (e.g., conservation of habitat trees, dead wood), and forbid activities that may deteriorate the ecological integrity, such as fertilization, draining, and use of pesticides.

Specific goals to gradually improve the ecological value of forests by applying lower harvest rates, aiming at more indigenous species and mixture, more deadwood and the conservation of habitat trees and valuable open spaces. These principles were also promoted towards private forest owners, expanding the 'mindshift' of forest management from production towards multifunctionality and conservation.

Finally, the implementation of the EU Bird and Habitat Directives further enhanced the integration of nature conservation aspects in forests. The network of Natura 2000 areas was legally established in 2002. It includes about half of all forests in Flanders. About ¼ of all forests are considered to belong to 'actual forest habitat'. For the existing habitats, criteria for the evaluation of the 'local status of conservation' were developed (for the forest habitats: Thomaes et al., 2009). They include distinctive thresholds for 'favourable conservation status', including aspects of tree species composition, stand structure, dead wood and overmature trees. Moreover, ambitious goals were set for habitat quality improvement, and for habitat extension for the coming decades in 2007. These extensions include both transformation of non-habitat forest (conifer and poplar plantations) and new afforestation activities.

Also, since the 1990s, a network of set-aside forests was established, covering by now about 5% of the forest area. They have both a scientific and conservation goal.

Over the last decades, forest restoration was thus focused mainly on gradual improvement of the natural values and level of naturalness and resilience of forests, by gradual conversion to mixed indigenous forests, and 'passive' restoration by conservation of habitat trees, deadwood.

A specific restoration effort was the large-scale removal of the invasive black cherry (Prunus serotina) in the understorey of the conifer forests on sandy soils during the 1990s. This project was only partly successful (see Section 3).

The success of the forest diversification policy is evaluated through the Regional Forest Inventory. The first inventory was performed in 1997–2000, and a second inventory in 2008–2017. Comparing both inventories shows important developments: Mixed stands have become much more predominant, with the share of exotic species gradually decreasing (Govaere and Leyman, 2022). Also many more old and dead trees are deliberately left unharvested, resulting in a strong increase in the share of very large trees and the average deadwood volume. Also, the average standing stock significantly increased (Vanhellemont et al., 2024).

Finally, specific efforts were done to overcome the strong fragmentation of forests in Flanders: several 'ecoducts' were built, crossing rail- and highways that cut through the most important forest areas. Although they prove to be effective, they cannot solve the fundamental aspects of fragmentation: low forest cover, small forest patches and intensive land use in the matrix surrounding them. Also, nitrogen deposition from traffic and livestock breeding poses a continuous pressure on natural ecosystems, including forests.

PERIOD 1: <1940

Section 1: General overview – how much, when and where

In this chapter, we will focus on two specific large-scale forest restoration initiatives.

- the large-scale afforestation of heathland areas,
- the restocking of devastated forests after World War I.

Afforestation of heathland

Based on an analysis of land-use changes on topographic maps (De Keersmaeker et al., 2023), we can quantify the afforested areas over time. Over the last 250 years, a total of about 70.000 ha of heathland was afforested. Most, about 51,000 ha, took place between 1780 and 1880, and were on common lands, consisting of heathland on poor sandy soils. They were mainly located in the north-east of the region. After 1880, another 20,000 ha was afforested. Before World War II, the efforts amounted to about 10,000 ha, with 7,000 ha more after the war, part of which were second generation plantations on clearcuts. The evolution of the forest area is illustrated in Figure 2, showing the land-use changes, mostly from heathland (and the last interval also grassland) to forest, but also the loss of forest, mostly for arable land.

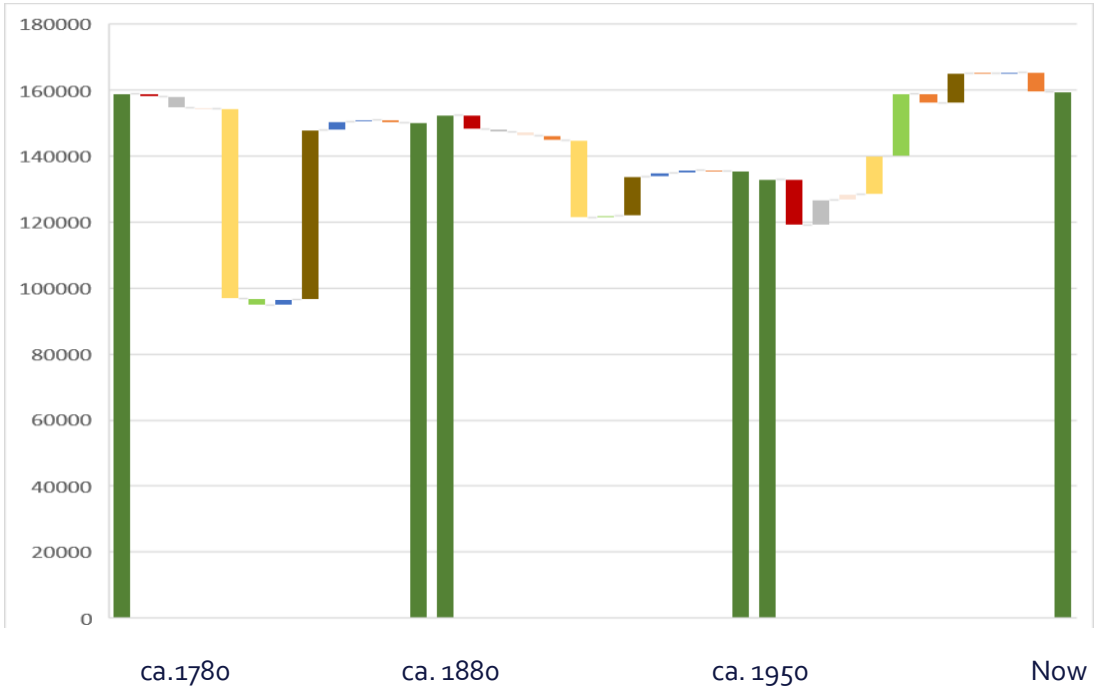

Figure 2. Changes in forest cover (ha) over the different time periods : losses to cropland (yellow bars) are compensated by afforestation, mainly of heathland (brown bars) and in the last period also alluvial grasslands (bright green bars); red/orange = losses f for infrastructure (source: De Keersmaeker et al., 2023).

These afforestation efforts were mainly driven by economic goals: to transform the low-productive grazed heathlands into production forests, mostly with conifers. Before 1940, most plantations consisted of Scots pine (Pinus sylvestris), after World War II, also Corsican black pine (Pinus nigra calabrica) and larch (Larix decidua and Larix leptolepis) were planted.

It should be noted that these afforestation activities did not lead to an increase in total forest cover: they were balanced by deforestations on comparable surface. Between 1780 and the 1950s, deforestations were mainly to create extra farmland (mainly cropland); after 1950 mainly to infrastructure (De Keersmaeker et al., 2023).

Afforestation was carried out by the forest service itself (on state land), but also by communities. They were stimulated to afforest their heathlands by an exemption to pay taxes on these lands if they were afforested.

The afforested areas cover more than half of the full current forest extent in Flanders. They are mainly situated in the north-east of the region, the so-called Campine district, where sandy soils prevail. Also in other parts of the region (e.g. surroundings of Bruges) where poor sandy soils occur, heathlands and 'wastelands' were afforested.

From an economic perspective, these efforts were a great success, providing industrial roundwood for the upcoming industries (especially to be used in shafts of the mining industry). From an ecological perspective, they lead to a strong decrease in open areas with high natural value. Also, the new afforestation activities were 'counterbalanced' by further gradual deforestation, mainly on fertile soils, for agriculture and infrastructure, resulting in a status-quo, but strong geographical shift of the forest cover.

Restocking of damaged forests after World War I

A second, specific forest restoration initiative are the reforestations that were performed between 1920 and 1930 in existing forest areas that were destroyed due to shelling or were pillaged by the occupying forces during World War I (1914–1918). A total forest area of approximately 5,000 ha was completely obliterated due to shelling and bombing, at both sides of the frontline.

Another 10–15,000 ha in the 'hinterland' were plundered and deprived of all valuable and useful wood. In the forest near Halle (Hallerbos), for example, more than 500 ha were cut, and two transportable sawmills and railtracks were installed to process and transport the wood.

A report in 1920 by the head of the Forest Administration) gives an inventory of all damaged forests. It mentions a total surface of 22,000 ha, and the damage is estimated at 175 million francs (Tallier, 2003). The restoration of these forests was part of the 'restitution payments' by the state of Germany, imposed by the Versailles treaty. Most of the replanting was done by the owners themselves (state, community, private owners) and was financially compensated. In some state forests, replanting was done by several hundreds of German labourers (former prisoners of war). Furthermore, the German government had to supply the planting material. Each year, over 30,000 kg of seeds (acorns, beechnuts, pine seeds) and

over 10 million saplings had to be delivered and were distributed amongst the involved parties (for the whole of Belgium) (Tack et al., 1993; Tallier, 2003).

Section 2: Conditions prior to the interventions

Afforestation of heathlands

Most of the afforested heathlands were on common lands (community and state land) and had existed for several centuries. Probably, most of the original mixed broadleaved forest (mainly oak and birch, but also beech, lime, hazel) had already disappeared or was heavily degraded by the full Middle Ages (11th–12th century). The transformation to heathland and so-called 'wastina' (wasteland with scattered scrubs) was the result of overexploitation and overgrazing. Vegetation consisted mainly of Calluna vulgaris and Molinia caerulea, with solitary coppiced oak and birch trees, and the soils quarternary deposit sands that were strongly podsolized and lessivated.

These lands had a limited economic value, but over the centuries developed a specific management regime that was essential for the (economic) survival of local shepherds who grazed their herds on these lands. The heath was also mowed and used as litter in stables and mixed with the excrements to produce fertiliser for small fields ('potstal'-system). Sod cutting was performed in wet areas to harvest peat.

Due to the import of much cheaper wool from the UK, and the growing demand for industrial timber, the traditional use of the heathlands came under pressure, and owners were stimulated to afforest the land, and transform these 'wastelands' into 'productive land'.

Post-war restoration project

Unlike the heathland afforestation, most of the land involved in the post-war restoration was located on fertile soils and consisted of medium-to-high productive forests. Most of these forests consisted of broadleaved stands, often coppice-with-standards with good quality Quercus robur in the standard layer, and coppice of hazel, hornbeam, oak, etc. Some parts were middle-aged conifer or beech high forest stands.

During the war, forests in the frontline were often of high strategic importance, located on hills and providing cover for the troops. They were heavily destroyed by artillery shelling from both sides. Figure 3 illustrates the complete destruction of these forests. Not only was the tree layer gone, but also the forest soil was completely ravaged.

Figure 3. Two pictures of the forest of Houthulst, after the shelling and recent. (left: postcard from 1919; right photo 2007: Kris Vandekerkhove)

Moreover, similar valuable forests in occupied territory were plundered. All valuable timber was systematically harvested and removed. What was useful at the frontline was transported to the west, valuable timber was transported to Germany as war booty, leaving only the small, invaluable trees.

Both private and public forests were affected: the report of Crahay from 1920 (cited in Tallier, 2003) mentions about 10,000 ha of private forests affected, 3,000 ha of state forest and 7,000 ha community forests. About 1/3 were devastated by artillery shelling, the rest by looting. Most of the valuable forests on rich loamy soils in the south of Flanders were affected. Only the Sonian Forest, south of Brussels, was spared as local forest officials could convince the occupying forces of the unique value of this forest (Tallier, 2003).

Section 3: Technical aspects of the interventions

Restoration goals: timber production, reclamation of low-productive land; (erosion protection)

Reference: Generally speaking, restoration initiatives during this period did not consider a reference ecosystem when designing the projects. This is because forests were rehabilitated following economic factors (resulting in plantations of the most productive tree species, mainly pine) rather than by trying to restore a reference ecosystem

Approach: active planting and tending on former open land, and on clearcut forest areas

Type of intervention: rehabilitation and ecological recovery through active rejuvenation of forests (also at the expense of ecologically valuable heathland and grassland areas)

Intervention activities: mainly cessation of deforestation, cessation of forest grazing and active planting of trees; sometimes with fertilization and soil preparation (ploughing, digging, draining) on very poor soils before planting.

Species used: afforestation mainly with pines (mainly Pinus sylvestris, as native species); sometimes with Pinus pinaster (exotic), and trials with several exotic conifers; restoration of

broadleaved forests mainly with oak (Quercus robur and petraea) and beech (Fagus sylvatica).

For broadleaf forest restoration, mainly local provenances were used (but: see German restoration plantings in Belgium with German seeds and seedlings). For pine, non-native and native provenances were used and tested.

Techniques: active planting of trees; sometimes with fertilization (metal slag) and soil preparation (ploughing, digging, draining) on very poor heathland soils before planting.

Heathland afforestation

The afforestation of the heathlands was very labour-intensive. Before planting, the vegetation was mowed and burnt and manually spaded. In areas where shallow hard podzol layers occurred, this layer was 'broken', and soil was worked up to 60 cm deep. In many cases, fertilizer was added before planting. This consisted of so-called 'metal-slags', from the iron industry, containing oxides of calcium, magnesium, silicon, iron, and aluminium, with lesser amounts of manganese and phosphorus.

The area was densely planted (0.5 x 0.5m) with monocultures of conifers. Between 1850 and 1880, Pinus pinaster was often applied, but due to widespread frost damage and lower stem quality, it was replaced by Pinus sylvestris, making up about 100% of all afforestation activities. Young plants were weeded and pruned, and first thinnings were performed after 8–10 years. Thinnings were repeated every 4–8 years, until the final product was harvested at the age of 30–60 years, when stem diameters of 20–30cm were reached.

By the beginning of the 20th century, also heavy machinery was used to plough the area. From the 1920s onwards, Corsican pine and larch became more popular. In this same period, the mid-aged Scots pine forests were often underplanted with black cherry (Prunus serotina), as it was considered an interesting timber species on these poor soils. The litter of this species would also improve the humus development and decomposition in these forest stands, where the conifer needle litter accumulated. There were also experiments with many non-native species, but except for American red oak (Quercus rubra), with little success.

Figure 4. Left: Afforestation with deep shoveling (ImageBank Drents Landschap); right: landscape with old pines and large areas of recent afforestations in Pijnven at the beginning of the 20th century (Massart, 1912b)

Post-war restoration

Immediately after the war, many of the devastated woodlands in the frontline were taken over by local farmers. There had been famine during the war, so state administrations were quite tolerant towards these (illegal) conversions to arable land of former forest. The most striking example is the forest of Houthulst, covering about 1,000 ha before the war, but only restored over 300 ha afterwards. The remaining 700 ha were converted to farmland. Reforestations in these areas required the removal of remaining explosives, levelling of the land and full replanting, often of over 90% of the surface.

Several deadly accidents occurred in this operation. Replanting was done in the mindset of forestry of that time: aiming at even-aged single-species high forest, mainly of oak.

In the looted forests in the hinterland, restoration often meant the removal of the remaining (low quality and dimension) tree layer, and a similar full planting of single-species stands.

In both cases, the first years after planting the young trees were cared for (removal of bramble and other suffocating vegetation), and then regularly thinned. So, after the war, these forests were quite drastically transformed from mixed coppice-with-standard forests towards even-aged high forest stands, mostly of oak and beech. Most of these stands are now fully grown even-aged broadleaf stands, where an understory and admixture are gradually coming in.

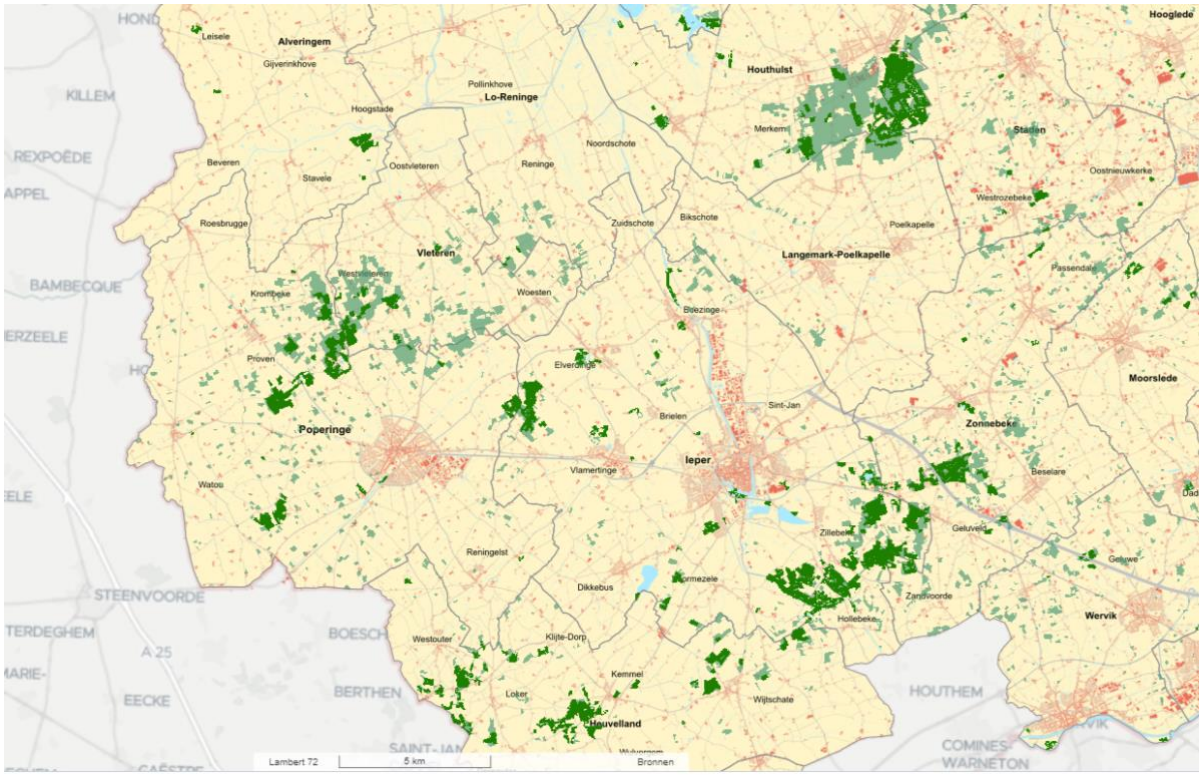

Figure 5. Area around Houthulst and Ypres (right). Bright green: remaining, restored forests; pale green: forest lost and mostly transformed to farmland after World War I (source: De Keersmaeker et al., 2001; Geopunt Vlaanderen).

The resulting young, even-aged high forest stands had regained their economic potential, but replaced much more diverse, uneven-aged and mixed forests. It would take at least a

century before they also gradually regained their pre-war structural and age diversity, ecological integrity and biodiversity.

Section 4: Socioeconomic and political aspects of the interventions

Landowner: Most afforestation and restoration activities were conducted on public land (state and community owned). Some larger private landowners joined in. Communities were promoted to join in by tax reductions and active support in the afforestation. There was some resistance from local farmers who used the public lands for the grazing of their cattle, but this resistance was low and faded fast, as most of these traditional farmers switched to other income sources (in the raising industry).

Funding and funding beneficiaries- Budget - Costs: the state invested in the afforestation of its own lands and gave logistic support (access to knowledge, nurseries, seeds, ...) to communities to do the same. Communities were also awarded tax cuts for the public lands they afforested. So financial support was indirect and therefore difficult to estimate.

As discussed earlier, for the German restoration plantings of ravaged forests in Belgium: Germany had to provide labour and seeds and seedlings for the restoration.

Policies & instruments: logistic support & tax cuts

Protection designation: none; land use conversion and forest restoration to produce productive forests that provide wood mainly for industrial use (industrialisation).

Stakeholders: mainly communities and the state itself (for the afforestation activities); forest service and state in the case of the post-war restoration. In both cases, local communities and farmers or forest users were not involved, only local village councils (democratically elected) were involved and assumed to represent the community.

Heathland afforestation

The afforestation activities were primarily driven by macro-economic developments: increasing demand for industrial roundwood; declining market for wool, famine and depopulation of poor areas in the countryside. They were also stimulated by initiatives and incentives from the national government.

On state land, afforestation was performed by the state forest service, that was reinforced for this purpose and performed 'exemplary' afforestation. Incentives to urge communities and private owners to afforest heathland included lower or abolished taxes for newly afforested land. The state forest service also provided technical support on the practical organisation of the afforestation.

Opposition to the afforestation came mainly from local farmer communities who saw their grazing land disappear. This slowed down the process in some towns, but as the economic

model on which this traditional farming was built was disappearing, this pressure became smaller. Many of these people were gradually incorporated into the forest management or moved to the cities.

No overall figure exists on the total costs of the conversion, but they were considered an investment that would pay off later. The tax reductions were also a strong motivator.

Post-war restoration

As stated, these reforestations were most often performed by the owner (state, community, private owner), but they could claim their costs to the authority dealing with war damage restoration and could (in theory) get their planting material from the German deliveries, coordinated by the forest administration.

The total damage to the forests, to be compensated for through 'restitution payments' by the state of Germany, imposed by the Versailles treaty, was estimated at 175 million francs (Tallier, 2003). And the German government was required to deliver every year 30,000 kg of seeds (acorns, beechnuts, pine seeds) and over 10 million saplings.

The bankrupt German economy could not fulfill its financial obligations and -not seldom exaggerated- financial claims and invoices were frequently contested. Also, the supply of seeds and saplings did not meet the requirements, both in quantity and quality, so much of the replanting was done at the expense of the owners.

Section 5: Results, successes and challenges

Level of success: Moderate to good for the afforestation. Some of the plantations failed, and some beginners' errors were made, but overall, the afforestation was successful. As for the post-war restorations: these were good, most reforestations were successful and have led to moderate to good quality forest stands.

Land-use after intervention: quite intensive forest management (tending, thinning, harvest) for wood production.

Ecological condition past intervention, and ecological recovery: For the afforestation – from forest and wood production perspective, the afforestation activities can be considered successful; however, the afforestation of valuable open habitats (heathlands, grasslands) are generally considered to have resulted in an important decline in biodiversity. So higher ecosystem functions, lower risk of over-utilisation, higher fertility, but lower species richness.

For the post-war restorations, species richness, structural diversity and ecosystem functions were higher after restoration and over-utilisation reversed.

Area successfully restored: about 70,000 ha were successfully afforested. About all of the areas considered were successful, sometimes after second retry after first failure; after war

damaged forest covered about 22,000 ha. All restoration reforestations were successful. However, an important part of the area (probably around 5,000 ha) of forest that was devastated during the war was not restored but transformed into farmland.

Social and economic improvement: both the afforestation and restoration activities lead to restoration of (productive) natural capital; the pine plantations became an important source of income for the communities that owned them, and also to the state (improved welfare). It did lead to (or followed) an important shift in the local economy and culture, as the traditional landscape and its users gradually gave place to an industrialised society and industrial crop production.

Other success indicators: higher aboveground and soil organic biomass, higher hunting potential, less erosion, much higher timber yield, specific but limited job creation.

Obstacles: little resistance from local communities, as they were already evolving towards a more residential and industrialised society, with country people moving to the cities, and jobs in mining and industry. Lack of funding may have slowed down the process here and there but did not influence the outcome.

Payments and provision of planting material for the post-war restoration proved to be slow and difficult, with much lower quantities and low-quality planting material delivered.

Monitoring: no documented monitoring provided or planned; first NFI only dated from 1990. Yearly reports on rural statistics (per village, crop etc.) were, however, produced in this period and could be re-analysed to reconstruct the process and its success

Heathland afforestation

From an economic point of view, these afforestation activities can be considered a success, as they delivered the expected economic output. The plantations were relatively productive (reaching an average increment of 4–6 m³/ha year) and after 30–50 years provided the required offset product: mainly pine poles to support mining shafts. Between 1920 and 1960, these pine plantations provided the main source of income for many communities. In many cases, a first generation of pine plantation was clearcut and replanted.

This economic productive model, however, was gradually fading from the 1960s onwards, as the market for pine poles dropped due to the gradual closure of mining industry.

From an ecological perspective, these pine plantations, of low conservation value had replaced species rich ecosystems, and did not improve the soil due to their recalcitrant litter. These plantations were increasingly considered an ecological problem. Moreover, they appeared quite sensitive to plagues, and acid deposition.

Both from an economic and ecological perspective, diversification and transition were required. Some pine plantations were restored as heathland, or clearcut and replaced by other tree species, but most of them are gradually being converted to mixed forests by continued progressive thinning, stimulating the natural regeneration of a mixed broadleaved subcanopy. Many of these stands still survive today and consist of old pine trees (many over

100 years old) mixed with broadleaves (oak, holly, birch, rowan, beech) and gradually re-develop in the direction of the original natural vegetation.

Although their biological value is still questioned, compared to the original heathland ecosystem, their biological diversity has strongly increased over time, and now shows an interesting mix of conifer-related species (fungi, birds) and species of the mixed broadleaved forest, including rarities like goshawk, honeybuzzard and pine martin.

The admixture of broadleaved species also results in a gradual improvement of the soil conditions, developing more profound humus soil layers and better water and mineral supply. However, the continued acidifying deposition (in the past mainly sulphur, now mainly nitrogen) leads to unbalanced nutrient supply and hampers the soil recovery.

Post-war restoration

The restocking of the devastated forests after the war gave an important 'kick start' to these forests and restored their economic potential.

From a technical point of view, they can therefore be considered a success: the newly planted forests grew well and have developed into fully grown healthy stands containing satisfactory quality timber.

For the owners, the destruction by war and looting was never fully compensated, even in case the planting material was delivered or restitutions paid. It took the forest more than a century to reach comparable standing stock and growth levels as before.

Also from an ecological point of view, the resulting forests still haven't reached the pre-war structural, age and species diversity of most of the original stands.

PERIOD 2: 1945 TO 1989

Section 1: General overview – how much, when and where

In this second period, the main focus concerning 'forest restoration' was on the further increase of the productivity and growing stock of the forest stands. Total forest area remained approximately the same. Two main developments can be discerned:

- Conversion of coppice and coppice-with-standards to high forest
- Tending and thinning of conifer plantations to produce industrial roundwood, mainly for mining industries.

The conversion of coppice and coppice-with-standards to high forest covered about the complete area of broadleaved forests, especially the oak-dominated and mixed deciduous forests, covering about 50,000 ha.

The widespread use of fossil fuels (coal and later also oil and gas) had strongly reduced the economic relevance and value of firewood, and made the coppicing no longer economically viable. In these forests, the conversion was often a gradual process, by building up the growing stock of the reserve trees and regeneration, and abandonment of the coppicing itself. In some cases, a direct conversion was done, by planting of beech or conifers (Vandekerkhove, 2013; Vandekerkhove et al., 2016a).

In alluvial forests, the coppice was interplanted with clones of poplar. Flanders was at that time renowned for its fast-growing poplars with excellent timber quality. Also, wetland hay meadows (that were also no longer economically viable) were replaced with poplar plantations, covering in total about 15,000 ha. From an economic perspective, this can be considered as 'forest restoration'. However, from an ecological perspective, these conversions and afforestation activities were detrimental as the involved grassland ecosystems were very rich in species. The clearcut system applied to the poplars (with heavy machinery) was devastating for the vulnerable soils. Often drainage was applied. In the former coppice woodlands, the poplar clearcut system also negatively affected the species richness and structural diversity of the wetland forests.

The conifer stands (mainly pines), often originating from the early 20th century and sometimes also second generation planted in the interbellum, covered about 60,000 ha. They were managed to produce large amounts of industrial timber. This was achieved by regular thinnings in the early stages, and final fellings at the age of 40–60 years. This was a quite lucrative business, as the demand for industrial roundwood for mining shafts was high. When replanting, the Scots pine stands are often replaced by the faster growing larch (especially Larix leptolepis) Corsican pine (Pinus nigra laricio). Especially a specific cultivar, the 'Koekelare' was very popular, and was also used in neighboring countries. By the end of the 1980s, about 15,000 ha of forest was consisting of Corsican pine.

Section 2: Conditions prior to the interventions

Before the conversion of the heathlands, grasslands and coppice forests, all of these had limited economic value but were intensively used, mainly for local use. Due to economic and demographic developments, these (often ecologically very valuable) ecosystems were abandoned and transformed to meet the economic demands of the post-war society.

From an economic perspective, the conversions and management of the forests between 1940 and the 1980s can be considered as successful: the forests gained in economic value and delivered profitable goods and services to the industrial market. However, from an ecological point of view, the development is ambiguous. Full focus was on production, and little consideration was given to nature conservation: valuable forest structures and open habitats got lost. On the other hand, trees were allowed to grow older and larger (at least in the broadleaved forests). By the end of the 1970s and the 1980s, recreation became an increasingly important factor also on the management) and nature conservation was gradually introduced in forest management, with conservation of protected species, more diversification and subcanopy development in the conifer stands (because they are older, but also because the market for mining wood was declining), resulting in mid-aged forest stands that allowed for diverse management choices in the next period.

Indicators:

- Land use and management regime pre-restoration: Low productive coppice forests, and young afforestation areas (mainly pine)
- Main driver(s) of degradation: Over-use; young condition of the stands with low productivity
- Abiotic conditions: Low fertility (poor dry sandy soils) for most of the conifers; wide variety of soil conditions for the broadleaves: poor to rich, dry to wet soils
- Potential vegetation and forest characteristics pre-restoration: Potential vegetation in all sites is mixed broadleaved forest – pre-restoration characteristics of the forests: young pine plantations: low structural and species richness, low productivity, poor soils; coppice forests : rich in tree, plant and insect species but low in structural diversity and species of deadwood and late developmental phases; moderate productivity but producing a product (firewood) that lost its economic relevance
- Ecological condition pre-intervention: idem
- Sociopolitical conditions pre-intervention: Heathlands and coppice forests mainly used for local utility; lost their economic value due to macro-economic and demographic changes . Economic 'development' of these young forests and coppices lead to more economic return and benefits.

Section 3: Technical aspects of the interventions

Restoration goal was purely economic: enlarge and adapt wood production to better meet the requirements of modern industrial society. At the same time, the local use of wood products (firewood, utensils…) was replaced by fossil fuels and mass-produced products.

Reference ecosystem was not a major concern in the restoration, that was focusing on a productive high forest (broadleaved and conifer) producing roundwood of different species and sizes. From the 1970s onwards the principles of close-to-nature forestry (the 'Leibundgut School') was more and more introduced, with more emphasis on mixed stands and age structures based on indigenous species and avoiding even-aged clearcut systems, thus referring more and more to the natural vegetation of mixed, mainly broadleaved, well-structured forests (see Period 3).

Approach: gradual conversion of coppice to high forest in broadleaved stands with introduction of poplar clones (*Populus x euramericana*) in alluvial forests and American red oak (*Quercus rubra*) on poorer sandy soils; tending and ageing in conifer stands with rotations of 40–60 years; Replanting of clearcuts in conifers: more use of other exotic species such as larch (*Larix decidua* and *Larix leptolepis*) Douglas fir *(Pseudotsuga menziesii*) and Corsican pine (*Pinus nigra* subsp. *laricio*)

Type of intervention: gradual conversion in broadleaved stands; thinning, tending and clearcut in the conifer stands.

Activities: active interplanting of high forest productive trees in coppice stands: oak, beech and American red oak on dry soils; poplars in wetland forests; active afforestation with poplars of alluvial hay meadows; tending and clearcut system with replanting in the conifers: all activities focused on economic revenue

Species used: new species were introduced in existing forests: poplar clones (*Populus x euramericana*) in alluvial areas; American red oak (*Quercus rubra*), larch (*Larix decidua* and *Larix leptolepis*) Douglas fir *(Pseudotsuga menziesii*) and Corsican pine (*Pinus nigra* subsp. *laricio*) on dry, often sandy soils. Also conversion to high forest of oak (*Q. robur and petraea*) and beech (*Fagus sylvatica*).

Section 4: Socioeconomic and political aspects of the interventions

Socio-economic developments (macro-economic) are the main drivers for the conversion and management of forests: firewood and small-size utility wood are no longer needed due to widespread use of fossil fuels and mass-production of goods. Forests are aimed at the production of industrial quality timber. These developments were made **both in public and private forests, with small forest owners lagging slightly behind** larger owners (both private and public).

The conversion is **economically driven, and no direct subsidies** are involved. Use of new species is facilitated by trials and seed production in research institutions. The increased productivity of forests is promoted by the government, that aims for higher self-sufficiency and provision of raw materials after the war, both in agriculture and forestry. Legislation (National Forest Law) supports this development.

Protection designation: In this era (1940–1990) very little initiatives are taken for nature conservation in forests. Conservationists were mainly concerned about increased pollution and the loss of valuable open areas (traditional agricultural landscapes; wetlands being drained etc.) that are progressively transformed into intensive agriculture and infrastructure, and had little interest (and knowledge) in forests. The few forested reserves that were established at that time were the personal initiative of local managers.

Stakeholder involvement: Only the State Forest Service was particularly involved in forest policy and management and also managed the community-owned forests. Larger private owners were member of the Royal Belgian Forestry Society, but small private owners had little or no support and relied on the advice and service that was provided by the State Forest Service. Conservationists had little interest and impact on forest management.

The 1970 European Year of Nature Conservation was a leverage to also take conservation values into account in forest management. Also, from the 1970s onwards, forest academics gradually introduced the principles of close-to-nature forest management, particularly in the state forests. They also aimed for more public engagement and involvement in forests by introducing the 'week of the forest' with planting activities, etc.

However, local communities or the general public had little involvement (and knowledge) on the management choices and operations, led by foresters. Communities also had little interest in the practicalities of the management, as long as it resulted in a constant stream of income.

Section 5: Results, successes and challenges

From an economic perspective, the conversions were **successful** and led to higher yields and income, both for public and private forest owners. The average stock volume and wood quality of the stands significantly increased. Fertility of formerly overused soils also gradually improved. For these stakeholders (state, communities, forest owners), the developments were satisfying. From an ecological perspective, these developments were not favorable: a lot of structural diversity was lost and stands became more monotonous and dark, leading to loss of diversity in the herbal layer (Baeten et al., 2009) Also, more exotic tree species were used, and stands were very intensively managed for production, including clearcuts, removal of all dead wood, drainage of wet forests etc.

Maturing stands with more tree age and size diversity, especially in the broadleaved forests, was the only major positive trend in forests in relation to conservation and biodiversity.

Post intervention: forests at the end of Period 2 were mainly mid-aged, often monospecific stands of high forest, with limited structural diversity and little or no deadwood and relatively low biodiversity, but with moderate to good production (related to local fertility).

From a socio-economic perspective, there was a strong improvement of the forest condition, as productivity and income provision had significantly increased.

Other indicators: The overall productivity increased, carbon stocks (above and belowground) also increased. However, from a biodiversity perspective, the choices in forest management were often detrimental (clearcuts, drainage, no dead wood etc.) and leading to even-aged, monospecific forest stands.

From the 1970s onwards, forest recreation strongly increased, and so was the provision of recreational services of the forest, with installation of walking and horse-riding tracks, catering for the 'new' needs of local population and leading to more community wellbeing. Overall, public perception on forests and forest management was positive. Only with conservationists and academics, there was a raising awareness that more diversification and balancing of functions (including ecological functions) of forests was needed. An awareness that was gradually picked up by forest managers, especially when the vulnerability of monospecific forest stands to disturbances like acid rain became apparent and lead to lower tree and forest vitality.

Obstacles: little obstacles in the development, as it was economically driven

Stakeholder satisfaction: overall, forest owners and managers were positive about the evolution: high income and recognition of the manager authority; also with the general public, satisfaction was high as their expectations and needs were met (e.g., recreation). Raising awareness on the ecological drawbacks and risks (acid rain), and increased opposition against large-scale harvests lead to gradual acceptance that more diversification was needed.

PERIOD 3: >1990

Section 1: General overview – how much, when and where

Gradual conversion to multifunctional forests

As stated before, the forest in Flanders has a long history of low forest cover, intensive use and periodic disruptions in periods of war and political instability. In Period 1, focus of forest management was therefore to restore the economic potential and value of forests, by investing in afforestation and the development of even-aged, monospecific forest stands and timber quality. Ecological and conservation considerations had little impact. This was continued in Period 2, in which the focus was mainly on productivity in the existing and recently established forests.

With the new Forest Decree (1990), a new mindset, focusing on multifunctionality and ecological integrity of forests, was generally introduced. Forest policy and management, both in public and private forests, was to balance economic, ecological and recreational goals.

This overall target for forests was applied and stimulated over the full area of Flanders, both in private and public forests (ca. 140,000 ha in total).

Restoration activities involved the promotion of mixed stands, promotion of the use of indigenous tree species, conservation of old trees and deadwood, abolishment of large clearcuts, designation of forest reserves (set-aside), restoration of natural abiotic conditions, etc.

Section 2: Conditions prior to the interventions

As stated before, most forests in the 1970–1980s were fragmented, consisting of relatively young and even-aged (average age 40–80 years) stands, and an important share of conifer and non-native plantations (>50% of the forest cover). Many of these forests were the result of 19th and 20th century afforestation activities, with only 15% of the forest consisting of ancient woodland (De Keersmaeker et al., 2001), and an intensive forest management aimed at industrial roundwood production. Amounts of deadwood and habitat trees were very low. This resulted in relatively low biological diversity.

Acid depositions had an important impact and were a major concern, as forest vitality was obviously affected, ground vegetation and forest soils degraded.

Apart from efforts to reduce the deposition, it was clear that the forests needed diversification to become more resilient to these pressures and simultaneously enhance the ecological value of these forests.

Forest policy and administration had recently been moved from the federal to the regional level, and most people at the newly organised administration were formed in the central-European forestry school, focusing on multifunctionality and close-to-nature forestry. Also private owner organisations were, although reluctant in the beginning and worried about income loss, open-minded for the paradigm shift, and cooperative in developing incentives for this conversion.

Due to the development of an open market of wood products, the economic importance of forests also decreased. Wood processing industry in Flanders primarily depended on imported wood. Recreational and ecological and other non-timber 'ecosystem services' became more predominant.

Indicators:

- Land use and management regime pre-restoration: see Period 2.
- Main driver(s) of degradation. Excessive homogeneity, acidification, eutrophication, vitality decline (pollution-acid rain), intensive logging.
- Abiotic conditions. Very diverse from poor dry sandy soils up to wet and fertile soils, all forests subject to acidification due to atmospheric depositions.
- Potential vegetation and forest characteristics pre-restoration. See Period 2.
- Ecological condition pre-intervention. Low species and structural diversity, moderate to high productivity, intensive use, some planted exotic species (Prunus serotina, Quercus rubra) become invasive and are present in almost 50% of the forest area, bad physical conditions by acidification and eutrophication due to atmospheric depositions
- Sociopolitical conditions pre-intervention. Triggered by problems in health condition of the forests, and incentives from academics and conservationists, a shift in paradigm was initiated, from a focus on production (and even aged monoculture) towards multifunctional, mixed forests managed according to close-to-nature principles. The new legislation (Flemish forest decree) in 1990, containing this new goal and approach, was an important event in this context.

Section 3: Technical aspects of the interventions

Based on the framework of the Forest Decree, several policy targets are set:

- Increase of the total forest area by 10,000 ha (net increase)
- Gradual conversion of non-native forests and mono-specific even-aged stands towards mixed, uneven aged forests, dominated by native species
- Conservation of natural site conditions, and species adapted to the site
- Close-to-nature management, avoiding or restricting clearcuts, conserving habitat trees, dead wood, waterbodies and valuable open patches etc.
- Set-aside approximately 3,000 ha of forest in strict reserves

The long-term target is to develop mixed forests that are in line with the structures, functions and composition of the natural climax forest at the site. These are considered best adapted

to the site, resilient to pressures and diverse enough to provide a wide array of ecosystem functions and wood products.

The approach to reach this target is a combination of legislative instructions/restrictions, financial stimuli and education.

Felling permits and management plans should be in line with the overall goal, and based on the 'precautionary principle' and 'stand still principle', inscribed in the Nature Conservation Decree (1997), a set of restrictions were imposed:

- no mixed forest can be transformed to monoculture,
- no indigenous species replaced by exotics, or broadleaves by conifers.
- all management operations (including forest operations) should be evaluated for their impact on natural values; avoidable important damage is to be excluded
- activities that may deteriorate the ecological integrity, such as fertilization, draining, and use of pesticides are forbidden
- limited overall harvest rate (below the increment), no clearcuts over 1 ha in size, promoting selective single or group felling

At the same time, private owners and communities receive subsidies if they afforest or replant with indigenous species. Also, subsidies are given if the owner adheres to the Criteria for Sustainable Forest Management (CSFM), stimulating the integration of nature conservation in managed forests (e.g. conservation of habitat trees, dead wood). Specific teams (Forest Groups) that help private owners in adopting the new management approaches and giving them technical and practical support were set up and subsidised by the government. They play an important role as go-between of government and private owners.

In order to increase the forest area, subsidies are also developed for the acquisition and afforestation of open land (excluding valuable open areas). However, with little success (see below).

The goal for set-aside forests was realised by a legal framework on strict reserves, including a financial compensation scheme for both private and public forest owners who can deliberately apply for inclusion in the network.

One specific programme for active restoration that was performed in the 1990s, was the large-scale eradication of black cherry (Prunus serotina) an American species that was introduced in the pine forests in the 1920s but turned out to be an invasive alien species that dominated the understory of many 1,000 ha of pine forests, obstructing the natural development of a mixed indigenous understorey and admixture.

A large programme was set up in 1994–1995 by the forest administration, organizing specific teams of field workers to restrain and eradicate this species in public forests. Private owners received subsidies to do the same. Larger shrubs were cut down, and the stumps smeared with glyphosate. Younger plants were sprayed on the leaves with a glyphosate-solution.

Between 1994 and 2010, over 7,000 ha of forest and heathland were treated, with a total cost of 4.6 million euro (Vanhellemont et al., 2008; ANB, 2015), but with variable success rates. In some places, the removal of black cherry gave room to a well-developed and mixed regeneration of native species. In these cases, regeneration of black cherry is not absent but does not regain its dominant position (Vanhellemont, 2009). However, in other forests, especially where no native regeneration was present to take over the understorey, a new generation of black cherry replaced the previous. There were not enough resources to organise a good follow-up. Other priorities and concerns about the use of glyphosate (ANB, 2015), the high cost (approx. 500 euro per ha) and low effectiveness of alternatives finally brought this initiative to a halt. Some initiatives are still taken and subsidised to suppress the species, but no longer coordinated and at this large scale.

Indicators:

- Restoration goal(s).Biodiversity protection, water provision, quality and hydrological stability, timber production, recreation, pollution mitigation, reduce disaster risk,
- Reference ecosystem. Multifunctional close-to-nature forestry uses the current natural forest (related to the local natural abiotic conditions) as the reference for management interventions, species composition, etc.
- Approach. Gradual transition towards more mixed, structurally rich forests through active measures (planting, selective cutting, restoration of water table) and natural processes (ageing, dead wood conservation, natural regeneration). For the case on Prunus serotina: active eradication by felling, extracting the roots and even herbicide treatment
- Type of intervention. All: Reduced impacts: lower harvest intensity; remediation : e.g., removal of exotic species, restoration of water table; ecological recovery : working towards mixed and highly structured stands; rewilding: in a network of set-asides (larger reserves and smaller set-aside patches within managed forests) – prestoration : applied in few cases, because of ongoing debate about the need to introduce new species or provenances.
- Intervention activities. Full protection (set asides, reserves, old-growth patches-approx 5%), keeping habitat trees, retention trees, changes in management regime from stand-scale to tree-scale interventions (close-to-nature), sowing, planting, invasive species control (until 2010 with herbicide, now forbidden), pesticides forbidden; soil preparation and soil amendments avoided as much as possible, thinning, logging, hydrological interventions (restoration), fencing, tree protectors, regulation of wildlife populations (roe, wild boar, etc.) girdling (only in invasive tree species control); no active management for old-growth elements but natural ageing and conservation of naturally occurring deadwood (snags, windthrow etc.) (ANB, 2001; Vandekerkhove, 2013; Vandekerkhove et al., 2013).
- Species used. Native tree species planted in rejuvenated areas and afforestation areas (approx. 30 species), if available from local and controlled provenances; Planting often in fixed patterns (e.g., 2x2) of at least 2,000 plants per ha, preferably mixed in groups. Recently also afforestation and subcanopy planting in clusters (clumps), with open space in between for natural regeneration. Soil scarification and

mowing nowadays only exceptionally applied (often done in earlier times); tree protection in areas with high browsing pressure and tending of the young trees by punctual manual mowing (brush cutter) until high enough.

- no active introduction of animal species: roedeer, wild boar, beaver, and even wolf, eagle owl and pine marten … are naturally re-expanding over the area. Special attention goes to conservation and use of local provenances and genetic diversity of these provenances; Considering GMO: only selected poplar clones (crossbreeding, not genetically modified) are sometimes used: their use strongly diminished due to their non-native character, but recently their assets for new afforestation activities are more and more recognised, and they are used again as 'ecosystem engineers'.

Section 4: Socioeconomic and political aspects of the interventions

Indicators:

- Landowner and land manager. Some 55% of the forest is privately owned, often in very small ownerships (< 1 ha per owner); conservation NGO's own about 5%; 20 % is state owned and another 20% community owned. Communities can get advice and receive technical guidance by the state forest service for their management. The private owners can rely on 'forest groups', NGO's that provide knowledge and help in the management of their forests (harvesting, replanting, management plans…). State forest managers play the 'exemplary leading role' in the forest transition, but also the advisors of private owners (in the forest groups) are convinced of the new approach and stimulate the owners to act accordingly (be it with more attention to costs and benefits). All forest managers are bound by very strict regulation and legislation that prevents any operation that deteriorates the ecological condition of the site (e.g., no large clearcuts, no transformation of mixed to monoculture, or from native to exotics).
- Sources and amount of funding. State forest service receives an annual allowance, and the income of harvests to finance its management: there is no state 'enterprise' that should realise profit or break-even : services to the public and to the environment are also taken into account. Private owners and communities receive subsidies for replanting of native species, for afforestation, making of a management plan, etc. If they accept higher ecological standards (or have to adhere to them, e.g., in Natura2000), fixed in a management plan, they receive a subsidy to compensate for income loss and increased costs. Amounts vary between 50 and 125 euro per ha per year. For set-aside areas, the amount may rise up to 400 euro per ha per year.
- Funding beneficiaries. All owners (NGO, private owner or communities) except for the state forest agency, are entitled to subsidies as mentioned above
- Budget. No information available, but the total amount of subsidies for management of forests and nature reserves combined is over 10 million euro. At least half of this amount will be for forests.

- Cost of interventions. Subsidies are expected to cover 80% of the real costs, thus at least 5–6 million euro per year
- Policies and instruments supporting restoration. Flemish Forest Decree of 1990 and the Nature Conservation Decree of 1997 form the legal basis for the restoration. Subsidies are regulated in the so-called 'executive orders'. Specific orders regulate the subsidy for management plans, for afforestation, for public access to private lands, for nature conservation measures (set-aside, specific management with conservation of habitat trees, dead wood…). Additional funding is provided (in Natura 2000) by LIFE or Interreg, but these amounts are for specific areas and are limited compared to the above.
- Protection designation. About 1/3 of all forests is located in Natura 2000 (50,000 ha); around 6,000 ha is in private nature reserves (owned by NGOs) and 4,000 ha in state nature reserves (of which about 3,000 ha set-aside). In Natura 2000 higher standards for conservation are imposed, but can be compensated by subsidy.
- Stakeholder groups. Regional administrations (state forest service = ANB) execute the management of state forests, and organize all permits and subsidy administration. Communities can rely on the regional administration (ANB) for technical support in the management of their forests; private owners can rely on the 'forest groups' (NGOs partly financed by a percentage on harvest sales, and partly subsidised by the Provinces = local administration).
- Stakeholder involvement. See before; new legislation and subsidies are always discussed in an advisory board, involving all stakeholders (NGO's, communities, farmer and industry organizations…).

The gradual (and still ongoing) conversion towards mixed indigenous forests is made possible by combining and balancing legal restrictions and financial stimuli.

Most of these resources come from the Flemish Government budget; in some cases also from European financing (LIFE, InterReg).

For state forests, revenues from wood harvest are supplemented with a yearly dotation to the forest service in order to provide ecosystems services (e.g. recreational infrastructure) and to implement the ecological quality goals. Over the last decade, these efforts have been more and more focused on the realisation of quantitative and qualitative goals of habitat types within SAC of the habitat directive.

Communities and private owners are financially compensated for potential income loss due to this transition and related restrictions, through a wide range of subsidies. They can be considered as a PES (payment for ecosystem services).

There are specific subsidies for

- Planting (or natural regeneration) of native species
- Acquisition of land to afforest
- Setting aside specific forest areas

- Adhering to specific conservation goals for forest habitat types
- Conception of a management plan

All of these subsidy schemes were developed in close collaboration and negotiation with private owner representatives, in order to come to a balanced compensation.

No overall figures are readily available to assess the overall financial cost of this policy.

Section 5: Results, successes and challenges

The success of the forest diversification policy is evaluated through a number of indicators (cfr. MCPFE, 2022) that can be derived from the Regional Forest Inventory (Govaere & Leyman, 2022), and are also reported (for Belgium) in the Forest Europe reports (MCPFE, 2003, 2007, 2015)

The first Flemish Forest Inventory was performed in 1997–2000, and a second inventory in 2008–2017, and a third inventory ongoing. Comparing inventories shows important developments. Mixed stands (<80% domination by one species) have become much more frequent: from 45 to 58% between the two inventories.

- the share of stands dominated by exotic species is gradually decreasing (38 to 30%)
- more very large trees are present
- dead wood amounts have increased from 13 to 23 m³/ha

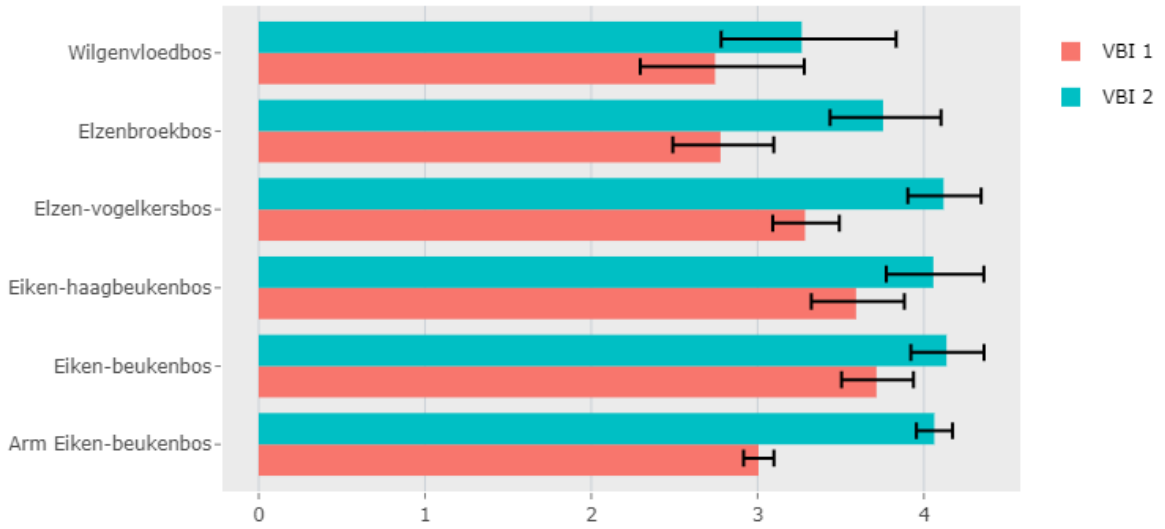

Figure 6. Number of tree species per plot, for different forest types in Flanders: for all forest types, a clear increase in species richness is observed. (Govaere & Leyman, 2022)

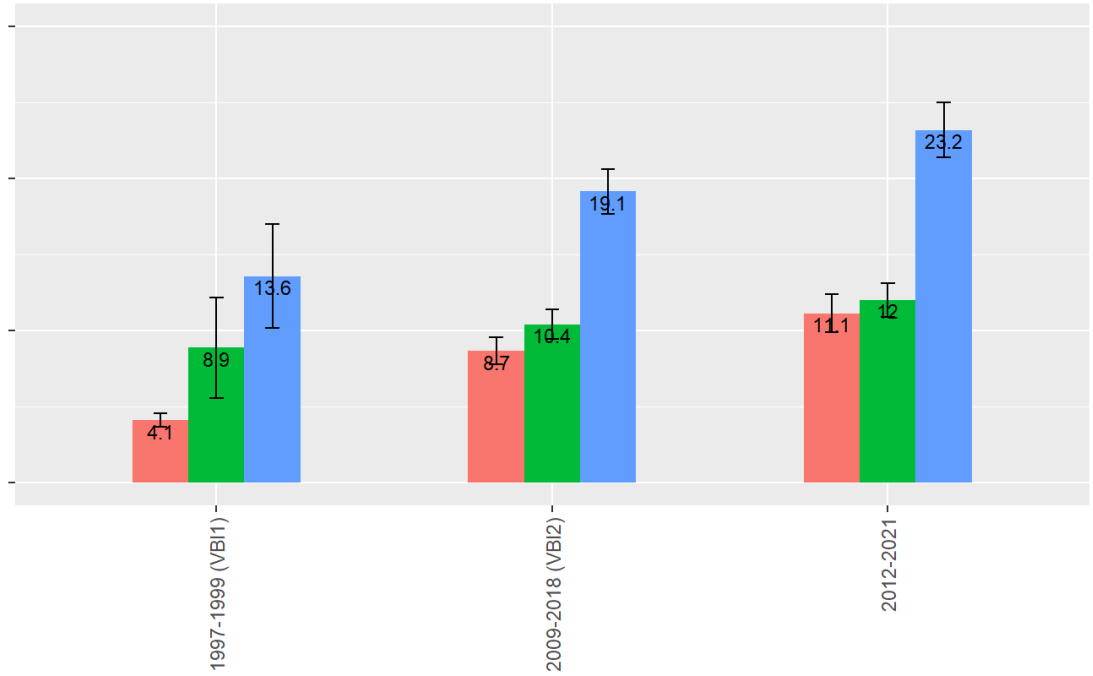

Figure 7. Dead wood amounts during first, second and third inventory; red=standing; green = lying; blue=total

- the average standing stock also significantly increased, from 216 to 274 m³/ha (resulting in more carbon stored and better resilience), indicating that the harvest rate is quite low, with probably less than 2/3 of the annual increment harvested (Vanhellemont et al., 2024).
- the figures on the presence of *Prunus serotina* indicate the mixed success rate. The share of plots where the species occurs increased from 1/5 to 1/4, indicating that the species is (re)colonising, though figures from pre-intervention are missing to fully assess this success.

On set-asides, the program was quite successful with 3,000 ha of forest reserves realised by the year 2000. They are now merged with other nature reserves, so further development is difficult to assess. The success of these set-asides was mainly due to a positive mindset towards the concept by state forest managers, proposing most of the sites, and a clear procedure for inscription. A contract-based procedure for private owners had little success, although financial compensation was adequate. The lack of interest was mainly due to uncertainty or mistrust on long-term implications.

The program on afforestation and forest expansion had limited success. The provided subsidies and financial means for the state forest service were insufficient to allow for larger scale afforestation. Legal restrictions on the afforestation of farmland and pressure from the farmers lobby created additional barriers and obstacles. The new afforestation activities over the last 30 years barely outbalanced the continued loss of forest (e.g. for infrastructure works). It was only over the period 2020-2024 that an important boost in funding and staff (and political support/pressure) led to a significant net expansion of forest area (+1,000 ha in four years).

Indicators:

- Level of success. Good
- Land use and management regime post-intervention. Clearcut and even-aged forests have largely been converted to mixed uneven aged forests where continuous cover forestry and group fellings are the standard. Only in the event of direct conversion of exotic trees (Corsican pine, Larch, poplar), clearcuts are still performed. Some conifer and poplar plantations have also been converted back to heathland and grasslands (as a nature restoration intervention), often financed by LIFE-projects.
- Ecological condition post-intervention. Significant increase of species richness (mixed tree species) and structural diversity; better resilience and habitat quality; fragmentation, low connectivity and threats by atmospheric deposition (also deterioration of physical conditions) however remain unaltered; over-utilization is replaced by low intensity harvest;
- Ecological recovery. Considerable improvement: see also the reappearance of forest quality indicators (saproxylic beetles, fungi, butterflies and hoverflies etc.) (Vandekerkhove et al., 2011)
- Area successfully restored. Large majority of the full forest area has significantly improved in structural diversity and quality; fragmentation and external pressures remain problematic
- Socioeconomic improvement. ***Community wellbeing:*** people (owners and visitors) feel connected to the forest and come to the forest for their physical and mental wellbeing, and react when something harmful appears to be happening to the forest (e.g. when trees are felled); ***all stakeholders are well engaged;*** through the forest groups, private forests are ***better informed*** than before; technical knowledge on silviculture however is less developed in state organisations than before (because of diversified tasks); ***Natural capital*** is significantly improved (more species, more carbon, more resilient soils), ***Sustainable economics*** is debatable : direct revenue from forestry has decreased, and costs increased, making the forestry in itself probably no longer economically viable but including the Payment for Ecosystem Services (= the subsidies), a break-even and even small profit is possible, but not to sustain a livelihood.
- Other success indicators. Only timber yield is probably lower than before, and connectivity and job creation remained stable; all other indicators improved.
- Main obstacles. Main obstacles in the beginning were limited financing or distrust of private owners (has diminished over the last years); some conflicts on management goals (restoration of heathland vs. forest diversification), conflicts with farmer organisations, bad spatial planning and farming legislation (and budget) are the main obstacles to reach the goal of forest area extension (only 1,500 of 10,000 ha realised), as more forest means less farmland available. Major obstacles for further quality improvement are external factors: atmospheric deposition, pollution and fragmentation (small forests isolated by infrastructure and intensive farming).

- Monitoring. NFI in 3000 permanent plots; habitat quality assessment for Natura 2000 habitats every 6 years.
- Level of stakeholder satisfaction. ***Satisfied:*** most stakeholders are quite satisfied by the level of financial and practical support (e.g. help from Forest Groups). The strict regulation that limits management choices and the high administrative burden can be a source of frustration for some forest owners. Decline of economic revenue and delivery of qualitative wood products are a concern to some owners and the wood processing industry, that was already small but further decreased over the last decades. A good balance between conservation and recreation goals versus wood production is not evident. Also changes in the international market, with more untreated roundwood directly exported to the far east (so no added value for the local economy) is an undesired development.

SUMMARY TABLE

Indicators	<1945	1945–1989	>1990
Forest area restored	60,000 ha afforestation	7,000 ha afforestation; ageing of stands	1,500 ha afforestation Quality improvement
Number of projects/initiatives	Numerous	Small and scattered-	Small and scattered; Quality improvement: everywhere
Geographical distribution	Mostly in north-east	Overall	overall
Spatial scale	1–1000 ha	1–10 ha	Overall implementation, stand level application
Land use/management regime pre	Afforestation: Heathland Existing forests: mainly coppice	Ageing; gradual conversion of coppice to high forest	Gradual diversification of even-aged monospecific forest stands
Abiotic conditions	Afforestations: poor sandy soils; other forests: diverse	Afforestaton on wet alluvial grasslands and poor sandy soils	diverse
Forest category and type	Afforestation : pine plantation pnv: mixed broadleaved (oak, beech, alluvial alder)	Afforestation: poplar plantation	Everywhere: Development towards mixed broadleaved forest
Main driver(s) of degradation	Pre-afforestation: burning and grazing	Homogenisation; atmospheric deposition, fragmentation	Atmospheric deposition, fragmentation
Ecological condition pre (1–5)	Pre-afforestation: biologically valuable	Many young evenaged	Mid-aged, monospecific forest stands

Indicators	<1945	1945–1989	>1990
	heathland on degraded soils	afforestations – low diversity	
Restoration goals	Timber production; forest expansion	Timber production	Diversification for ecosystem resilience and E.S.
Approach	Active afforestation	Active afforestation and thinning	Active: diversification (selective thinning, mixed replanting,... + Passive: set aside and conservation of old and dead trees
Type	Afforestation	Afforestation and rehabilitation	Rehabilitation
Activities	Planting, fertilizing	Thinning	Diversification (selective thinning, admixture of species)
Species used	*Pinus sylvestris, non-native conifers (>80%)*	mixed	Native species (>80%)
Genetically modified organisms	No	No (Poplar cultivars ?)	No
Management for old-growth forest	No	No	Yes: passive (set aside; non-harvest of dead and old trees)
Land owner/manager	Public administration, forestry department; communities and private owners	Public administration, forestry department; communities	Public administration, forestry department;

Indicators	<1945	1945–1989	>1990
		and private owners	communities and private owners
Sources of funding	Public administration	Public administration	Public administration
Funding beneficiary	Forestry department, communities and private owners	Forestry department, communities and private owners	Forest and Nature department, communities and private owners
Budget /cost	?	?	?
Socioeconomic benefits	Timber production	Timber	Timber and non-timber Ecosystems services
Stakeholder groups	forestry department, communities, private owners	forestry department, communities	Idem + conservation and forest NGOs
Stakeholder involvement (1–5)	2	2	3
Level of success (1–5)	4	4	4
Land use/management regime post	Forest / Clearcut plantation	Forest mixed aimed at production	Forest multifunctional
Ecological condition post (1–5)	2	3	4
Ecological recovery (1–5)	2	3	4
Socioeconomic improvement (1–5)	4	3	3
Main obstacles	Conflicting goals with traditional users		Financial dependence; mistrust; pressure from other land users (farming lobby), especially against afforestation
Monitoring (yes/no) – Indicators	no		Yes: forest inventory and other indicators (e.g. area in reserves)

Indicators	<1945	1945–1989	>1990
Stakeholder satisfaction (1–5)	2	3	3

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FIGURES

TABLES