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Forest statistics from the National Forest Inventory in Latvia for 2004–2025

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Abstract

In the context of accelerating environmental change, local quantitative assessment of forest resources, both timber and non-timber ones, is highly valued for scientific and policy-making reasons. National forest inventories (NFIs) are conducted across Europe for this purpose; however, overall quantitative data on standing volume and forest structure are rarely published in scientific literature, limiting their accessibility to a broad international scientific audience. This study presents national statistics on forest characteristics important for commercial and conservation use, obtained from the NFI in Latvia, a forest-rich country and an important source of timber in Europe. In 2025, forests covered approximately half of the country's territory, and the forest cover area remained stable from 2005 to 2025. The majority of stands have been dominated by six species (Scots pine, Norway spruce, birch, aspen, black and grey alder), with conifers and deciduous species forming roughly equal shares; mixed stands were common. However, Scots pine numbers are revealing a declining trend as they are being replaced by deciduous species such as birch and aspen. The total standing stock showed a significant yet ceasing increase over the period covered by NFI data, adding 5% over the course of NFI measurements, and apparently was reaching an equilibrium with mortality and felling in 2025. The abundance and stock of the retention trees have roughly tripled. The average amount of deadwood remained steadily high with minor fluctuations, exhibiting a rising trend, achieving 19.4 $m^3 ha^{-1}$ in 2025. The lying-to-standing deadwood ratio was 1.68 to 1. Thus, the available statistical data indicate that forests in Latvia are stable and managed according to their productivity, while management systems maintain a high amount of deadwood.

Keywords: forest dynamics; eastern Baltic region; forest statistics; standing volume; forest structure

Introduction

In the context of accelerating environmental change and rising demand for timber and related products (Daigneault et al. 2022, Bousfield et al. 2023, Yayala et al. 2025), forests are experiencing growing stresses and transformations (Hartmann et al. 2022, Vacek et al. 2023). Such shifts imply the need for both informed and scientifically grounded decision-making (Cowie et al. 2021, Romeiro et al. 2022), especially with consideration of a broad perspective at national and regional levels to maintain forest productivity and services (Kauppi et al. 2022, West et al. 2023). The socio-economic and climate-related changes in forests, however, bear explicit regional and local specifics (Palmero-Iniesta et al. 2021, Gregor et al. 2024), necessitating localised solutions. Given that changes in productivity, structure, and composition of stands are considered as the principal threats for forest ecosystems in the Eastern Baltic region (Petit-Cailleux et al. 2021, Pretzsch et al. 2023, Reich et al. 2023), reliable scientific data (statistics) on these issues is anticipated (Breidenbach et al. 2021, Krsnik et al. 2023). This is further highlighted by the legislative requirements set by the EU Nature Restoration Law and the Green Deal (Liobikienė and Miceikienė 2023, Perissi 2025).

National forest inventories (NFIs) are a highly valuable source of reliable information/statistics (Breidenbach et al. 2021), which, however, are scarcely published in scientific media (journals), hindering the justification of research relevance and gravity (Bontemps et al. 2022). However, such data are widely published in the national language, organised as reports (e.g. Silava 2023), with limited international recognition/availability and high citation impact. Even though remote sensing is rapidly developing and starting to act as a major source of quantitative information about health and biomass of forests (Fassnacht et al. 2024), the accuracy regarding the structure and age of stands is still beyond that of instrumental data, as gathered in the NFIs (Bontemps et al. 2022). Furthermore, temporal trends in forest statistics obtained from NFIs are crucial for assessing ongoing changes in ecosystems (Hawryło et al. 2020, Breidenbach et al. 2021) and validating models (Sharma et al. 2011, Sharma and Breidenbach 2015, May et al. 2024).

The study aimed to report statistics derived from NFI on the cover, productivity, and structure of forests, as well as their temporal changes in Latvia. Despite its small size, Latvia is rich in diverse hemiboreal forests, and the forest industry accounts for 16–22% of its economy, making it a significant supplier of forest products to European markets (according to the estimates of Latvian Ministry of Economy for 2024). The climate in Latvia is cool and moist temperate continental (Kottek et al. 2006); nevertheless, under the ongoing climatic (Meier et al. 2022) and socioeconomic changes, particularly intensification and modernisation of forest management (Jansson et al. 2017, Himes et al. 2022, Kauppi et al. 2022, Nagel et al. 2025), forest cover and productivity, as well as the share of thermophilic tree species, have been increasing.

Material and methods

National Forest Inventory

The data presented are based on the full measurement dataset covering the period 2004–2025, four full five-year measurement cycles and part of a fifth. In Latvia, the National Forest Inventory (NFI) was established to monitor forest resources and to quantify changes in growing stocks for national and international censuses. The NFI structure in Latvia was developed based on the structure implemented in Lithuania, which in turn was borrowed from Sweden, but some details were adjusted to suit the age structure of stands and lowland conditions (plot and sub-plot sizes; Kuliešis et al. 2003).

In Latvia, the NFI gathers data from a network of 16,157 permanent sampling plots (in 2025), arranged in square tracts, which cover the territory of Latvia in a regular grid with a spacing of 4 × 4 km (Figure 1, upper map). The sample plot grid covers the entire territory of the country, and all of the accessible sample plots have been surveyed. Thus, the grid fully covers the local climate gradient, represented by the range of average annual temperatures and precipitation, which are 4.1–6.5°C and 550–850 mm, respectively. Measurements, however, were taken if trees were present in the plot (woodlands s.l.). This density of plots/sample plots was initially estimated to obtain reliable estimates of national growing stock (Jansons and Līcīte 2010). A detailed description of the methodology is provided in Jansons and Līcīte (2010).

In this study, the analysis included forest lands, i.e. lands covered by forests and lands under forest infrastructure facilities, as well as floodplain clearings, swamps and glades that are part of the forest and adjacent swamps. In turn, a forest is determined as an ecosystem in all stages of its development, where the principal net producers of organic mass are trees, the height of which at the particular location may potentially reach and exceed five metres, with the projection of the crowns exceeding 20% of the forest stand (open to closed canopy forests). These categories are included in the NFI. Other woodlands were neglected in this study. For each plot, data on land use category, ownership type, forest type, forest origin, management restrictions, and economic activity indicators were collected and recorded. Boundary sample plots were divided if more than 10% of their area fell into another (excluded) category.

The area of each permanent (circular) sampling plot is 500 m², within which, for all of the trees with a diameter at breast height (DBH) greater than or equal to 14.1 cm, DBH was measured, as well as their condition (living, dead, cut, damaged, etc.) recorded.

In a concentric subplot of 100 m², all trees with a DBH ≥ 6.1 cm were measured, and in a 90° sector of the same subplot (area of 25 m²), all trees (trunks) with a DBH ≥ 2.1 cm were measured. For a stratum of the trees by species and cohort (two to four trees), tree height was measured (± 0.2 m). Within the plot and subplot, fallen deadwood (tree stems) of respective dimensions (DBH or diameter at the thick end) were measured. For standing dead trees, DBH and height were measured; for broken dead trees, diameter at thick and thin ends were measured.

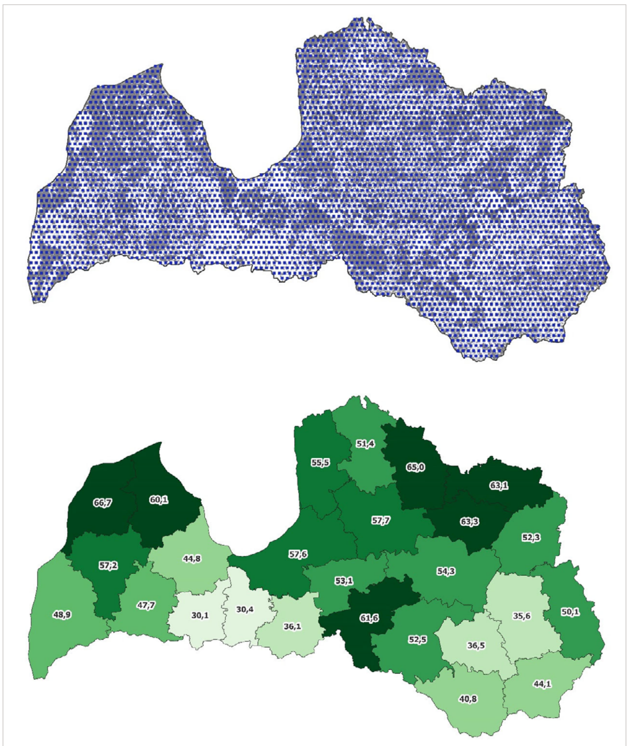

Figure 1. The top map shows the location of National Forest Inventory sites (blue dots) and forest cover (polygons in the background)

The bottom map shows the spatial distribution of forests in Latvia, estimated using relative forest cover (shading) by former administrative units, based on the latest inventory cycle (2020–2024).

Former administrative units are maintained for uniform and balanced representation of local forest landscapes, as used in the national forest inventory.

The understory and advanced regeneration were not included in the calculations as their share was negligible. Each year, one-fifth of the sample plots are visited for measurements and surveys, so that each site is revisited every five years. Detailed methodology for the NFI in Latvia is provided in Jansons and Līcīte (2010).

Data analysis

Conventional approaches commonly used for processing NFI data were applied to this summary; a set of characteristics of key forest attributes on the overall status and dynamics of forests was calculated. The volume of trunk wood for individual trees (living or dead) was calculated according to the equations proposed by Liepa (1996) and adopted as standardised. For broken trees (live and dead) without tops, the volume of trunk wood was calculated as for a truncated cone based on the last measured dimensions. Stand-level characteristics were calculated at the plot level. In the calculations, where appropriate, a forest element, i.e. a part of the forest stand represented by a cohort of certain species, was used for averaging. Relative and absolute distributions of forest land categories and their standard errors were obtained from plot data and expressed on a per total land area basis; in addition, the analysis was conducted for 26 former administrative units located around the largest cities and representing historical forest management units. When calculating increment, no special statistical processing was used to include trees (entering DBH strata described above), assuming mutual elimination of spatial effects at the level of the land plot and above. When calculating deadwood stocks, fully decomposed deadwood (Sandstrom et al. 2007) was excluded.

Results

Forest area

As estimated in 2025, the total forest land area in Latvia was 3494.7 ± 25.3 kha (error is derived from annual estimates during the moving five-year cycle), comprising 54.1% of the total land area or 6.45 Mha (Table 1). Among the forest lands accounted by the NFI, forests were estimated to occupy 3,318.3 kha, i.e. 95.0% of all forest lands and 51.4% of total land area. The area of strictly protected forests, where commercial felling is prohibited, was 281.5 kha, or 8.5% of total forest area. Yet the area has been stable through the reference period. However, it must be admitted that the NFI can underestimate the area of scattered stands/polygons.

During the period 2004–2025 covered by the instrumental NFI data, the area of forest lands and forests in particular showed a slight increase, which, given the standard errors, appeared non-significant. Similarly, a slight increase has been observed in neighbouring countries in the Eastern Baltic region (Pekkarinen et al. 2025). Though the only time-related increase in area, which exceeded the uncertainty (standard errors), occurred for clearcuts/cuttings (increasing from 1.4 to 2.5% of forest area in 2010

Table 1. Mean estimated (± standard error, *SE*) area of forest lands by type and protection status (strict protection) (in kha) during the period covered by the national forest inventory in Latvia

Type and protection status	2006–2010		2011–2015		2016–2020		2021–2025	
	Area	*SE*	Area	*SE*	Area	*SE*	Area	*SE*
All forests								
1 Forests	3225.6	25.4	3267.6	25.4	3297.3	25.4	3318.3	25.4
1.1 Stands	3176.8	25.4	3212.3	25.4	3241.9	25.4	3235.0	25.4
1.2 Degraded/damaged stands	4.7	1.4	3.2	1.1	5.4	1.5	6.5	1.6
1.3 Clearcuts/cuttings	44.0	4.2	52.0	4.5	49.9	4.5	76.8	5.5
2 Openings	33.3	3.6	28.7	3.4	29.5	3.4	29.1	3.4
3 Waterlogged openings, beaver fens	41.8	4.1	42.7	4.1	40.9	4.0	35.3	3.7
4 Forest infrastructure	86.1	5.8	91.4	6.0	97.8	6.2	101.3	6.3
4.1 Roads	17.5	2.6	20.5	2.9	23.7	3.1	25.8	3.2
4.2 Borderlines, fire breaks	18.2	2.7	18.5	2.7	19.6	2.8	17.8	2.7
4.3 Drainage system	50.4	4.5	52.4	4.6	54.5	4.6	57.7	4.8
5 Other forest lands	10.2	2.0	9.7	2.0	11.1	2.1	10.7	2.1
Total	3396.9	25.4	3440.1	25.4	3476.6	25.3	3494.7	25.3
Strictly protected forests (commercial felling is prohibited)								
1 Forests	283.2	10.4	281.7	10.4	281.1	10.4	281.5	10.4
1.1 Stands	281.7	10.4	281.3	10.4	279.1	10.3	278.2	10.3
1.2 Degraded/damaged stands	0.8	0.6	0.2	0.3	1.5	0.8	2.3	1.0
1.3 Clearcuts/cuttings	0.6	0.5	0.3	0.3	0.5	0.4	1.0	0.6
2 Openings	4.1	1.3	4.0	1.3	4.2	1.3	4.3	1.3
3 Waterlogged openings, beaver fens	2.6	1.0	3.0	1.1	3.4	1.2	3.0	1.1
4 Forest infrastructure	7.0	1.7	7.3	1.7	7.4	1.7	7.6	1.7
4.1 Roads	1.5	0.8	2.0	0.9	2.0	0.9	1.9	0.9
4.2 Borderlines, fire breaks	2.2	0.9	2.2	0.9	2.2	0.9	2.2	0.9
4.3 Drainage system	3.4	1.2	3.2	1.1	3.3	1.1	3.5	1.2
5 Other forest lands	0.6	0.5	0.6	0.5	0.6	0.5	0.8	0.6
Total	297.5	10.7	296.6	10.6	296.8	10.6	297.1	10.6

and 2025, respectively). Such changes indicated growing intensity of forest management (Daigneault et al. 2022, Himes et al. 2022), likely in response to increasing demand and/or improved growth due to the extension of the vegetation period and, therefore, increment (Kauppi et al. 2022, Pretzsch et al. 2023).

The spatial distribution of forests in Latvia remained heterogeneous, and, according to data obtained in 2025, the proportion of territory covered by forest lands ranged from 30.1 to 66.7% in the former administrative units in the central and north-western parts of Latvia, respectively (Figure 1). However, a general pattern emerged: forest cover was higher in the northern part of the country, which can be explained by differences in soil and climate. Administrative units with the most fertile soils and longer vegetative season, which facilitate agriculture, are located in the central parts of the country (Toth et al. 2008). The temporal shifts in the spatial distribution of forest cover, however, have been only slight, following the trend for the national means, though a somewhat stronger increase in forest area has occurred in the administrative units in the eastern part of the country (not shown). Such spatial differences in the increase in forest land can be related to socio-economic issues, as well as edaphic differences (Toth et al. 2008), namely the abundance of low-productivity arable lands, which can be reforested for convenience and economic reasons (Bousfield et al. 2024).

According to observations from the most recent inventory (2021–2025), tree stands were dominated by six tree species with relative abundance more than 5%, which accounted for 97.1% of the total forest land area (Table 2). The area occupied by coniferous and deciduous species is comparable, with the latter having a larger share (45.3% versus 54.7%, respectively), while forest areas where deciduous species predominated (for example, English oak, common linden, elm, etc.) accounted for only 1.8% of forest land. In the protected forests, however, species distribution was similar, though tree stands dominated by Scots pine were the most common. This complies with projected tree species distribution models, which project a gradual retreat of conifers in the Baltics (Buras and Menzel 2019, Reich et al. 2022). This also indicates a high degree of mixing at the landscape level (Rendenieks et al. 2017), which argues for forest resilience (Zamora-Pereira et al. 2021, Cantarello et al. 2024).

The most common tree species in forests were birches, Scots pine, and Norway spruce, which comprised 72.5% of the forest area (Table 2). During the analysed period covered by the instrumental data (2004–2025), tree species composition of the forests has remained relatively

Table 2. Mean estimated area of forest stands (± standard error, *SE*) by dominant species (in thousands of ha) and protection over the five years covered by the national forest inventory in Latvia. Numbers in brackets show the share of the total forest area. The area of Latvia is 6.45 Mha

Species	2006–2010		2011–2015		2016–2020		2021–2025	
	Area	*SE*	Area	*SE*	Area	*SE*	Area	*SE*
All forests								
Birches (*Betula* spp.)	881.3(28%)	17.4	883.8(28%)	17.5	890.5(27%)	17.5	882.3(27%)	17.5
Pine (*Pinus sylvestris*)	890.0(28%)	17.5	866.5(27%)	17.3	842.5(26%)	17.1	824.3(25%)	17.0
Spruce (*Picea abies*)	567.9(18%)	14.4	585.6(18%)	14.6	623.5(19%)	15.0	639.6(20%)	15.2
Grey alder (*Alnus incana*)	310.7(10%)	10.9	321.6(10%)	11.1	324.4(10%)	11.1	310.1(10%)	10.9
Aspen (*Populus tremula*)	253.3(8%)	9.9	268.0(8%)	10.1	258.3(8%)	10.0	262.8(8%)	10.0
Black alder (*Alnus glutinosa*)	166.4(5%)	8.1	185.2(6%)	8.5	202.8(6%)	8.9	221.5(7%)	9.2
Willows (*Salix* spp.)	42.3(1%)	4.1	43.1(1%)	4.1	39.0(1%)	3.9	32.9(1%)	3.6
Oak (*Quercus robur*)	21.4(1%)	2.9	20.2(1%)	2.8	24.5(1%)	3.1	23.6(1%)	3.1
Lime (*Tilia cordata*)	8.3(< 1%)	1.8	5.7(< 1%)	1.5	7.7(< 1%)	1.8	10.8(< 1%)	2.1
Ash (*Fraxinus excelsior*)	22.7(1%)	3.0	17.0(1%)	2.6	11.3(< 1%)	2.1	9.5(< 1%)	1.9
Maple (*Acer platanoides*)	4.0(< 1%)	1.3	5.5(< 0%)	1.5	8.5(< 1%)	1.8	8.7(< 1%)	1.9
Elms (*Ulmus* spp.)	5.1(< 1%)	1.4	6.4(< 1%)	1.6	6.4(< 1%)	1.6	4.5(< 1%)	1.3
European larch (*Larix decidua*)	1.3(< 1%)	0.7	1.2(< 1%)	0.7	1.2(< 1%)	0.7	1.6(< 1%)	0.8
Other species	2.0(< 1%)	0.9	2.5(< 1%)	1.0	1.4(< 1%)	0.7	2.6(< 1%)	1.0
Strictly protected forests (commercial felling is prohibited)								
Birches (*Betula* spp.)	66.3(2%)	5.1	66.9(2%)	5.1	65.8(2%)	5.1	64.4(2%)	5.0
Pine (*Pinus sylvestris*)	133.8(4%)	7.2	132.4(4%)	7.2	131.5(4%)	7.2	131.8(4%)	7.2
Spruce (*Picea abies*)	32.6(1%)	3.6	33.4(1%)	3.6	35.2(1%)	3.7	33.7(1%)	3.7
Grey alder (*Alnus incana*)	6.0(< 1%)	1.5	4.9(< 1%)	1.4	3.3(< 1%)	1.1	3.6(< 1%)	1.2
Aspen (*Populus tremula*)	14.8(< 1%)	2.4	14.5(< 1%)	2.4	14.5(< 1%)	2.4	15.4(< 1%)	2.5
Black alder (*Alnus glutinosa*)	19.2(1%)	2.8	20.5(1%)	2.9	21.1(1%)	2.9	23.0(1%)	3.0
Willows (*Salix* spp.)	1.2(< 1%)	0.7	1.2(< 1%)	0.7	1.2(< 1%)	0.7	1.2(< 1%)	0.7
Oak (*Quercus robur*)	1.6(< 1%)	0.8	2.0(< 1%)	0.9	1.6(< 1%)	0.8	1.6(< 1%)	0.8
Lime (*Tilia cordata*)	0.8(< 1%)	0.6	1.2(< 1%)	0.7	1.8(< 1%)	0.9	1.8(< 1%)	0.9
Ash (*Fraxinus excelsior*)	4.4(< 1%)	1.3	2.8(< 1%)	1.1	2.1(< 1%)	0.9	0.1(< 1%)	0.2
Maple (*Acer platanoides*)	0.4(< 1%)	0.4	0.8(< 1%)	0.6	0.8(< 1%)	0.6	1.6(< 1%)	0.8
Elms (*Ulmus* spp.)	0.8(< 1%)	0.5	0.8(< 1%)	0.5	0.4(< 1%)	0.4	0.0(< 1%)	0.0
European larch (*Larix decidua*)	0.0(< 1%)	0.0	0.0(< 1%)	0.0	0.0(< 1%)	0.0	0.0(< 1%)	0.0
Other species	0.0(< 1%)	0.0	0.0(< 1%)	0.0	0.0(< 1%)	0.0	0.0(< 1%)	0.0

constant, as the only notable increase in area, which exceeded the uncertainty (standard errors), was estimated for black alder and Norway spruce. Although Norway spruce has recently been severely affected by climate/weather changes associated with bark beetle infestations (Potterf et al. 2025), this species has remained widely used for post-logging restoration due to its tolerance to high ungulate pressure (Hardalau et al. 2024, Done et al. 2025). In turn, the increase in black alder forest (irrespective of status) cover might be related to the reforestation of former agricultural lands, where drainage system functionality deteriorates (Orczewska 2009, Vacek et al. 2016).

Growing stock

The total growing volume of forests estimated on the latest inventory (2021–2025) was 690.1 ± 7.9 million m^3, averaging 213.3 ± 2.3 m^3 ha^{-1} (Table 3). The temporal changes in the total standing volume have exceeded the uncertainty (standard errors), indicating a steady increase with a tendency to stabilise, similar to the neighbouring countries (Pekkarinen et al. 2025). As a result, the growing stock has increased by 36.1 and 35.5 million m^3 (10.5 and 11.2 m^3 ha^{-1}), when forest lands (including infrastructure) and forests were considered, respectively. Such an increase can be explained by the extension of forest lands (Table 1), as well as by the increase in productivity of stands due to the efficiency of management (Kauppi et al. 2022, Krsnik et al. 2023) and extending vegetation seasons (Meier et al. 2022, Pretzsch et al. 2023). In the protected forests, however, the increase has been considerably steeper, likely as the stands aged and trees grew.

The mean 5-year periodic increment of growing stock has shown a decreasing trend with a net reduction of 2.7 M m^3 y^{-1} (0.65 m^3 y^{-1} ha^{-1}, compared to 2025) over the

Table 3. The rolling five-year estimated mean (± standard error, *SE*) growing stock (million m^3) in forest lands and forests (forest stands and retention trees) of Latvia during 2004–2025. The last year of the five-year subperiods is shown. Numbers in brackets show the growing stock volume per forest area (m^3 ha^{-1})

Year	Forest land		Forests		Forest stands		Retention trees	
	Volume	*SE*	Volume	*SE*	Volume	*SE*	Volume	*SE*
				All forests				
2008	657.0(200.1)	7.1	654.5(203.6)	7.3	646.8(200.0)	7.3	7.5(2.3)	0.5
2009	656.3(199.2)	7.1	653.8(202.8)	7.3	645.5(198.8)	7.3	8.1(2.5)	0.5
2010	662.7(200.5)	7.2	660.2(204.1)	7.4	651.0(199.9)	7.4	8.9(2.7)	0.5
2011	667.0(201.2)	7.2	664.4(204.9)	7.4	654.3(200.3)	7.4	9.8(3.0)	0.5
2012	672.9(202.4)	7.3	670.3(206.1)	7.5	659.5(201.3)	7.5	10.6(3.2)	0.5
2013	677.2(203.2)	7.3	674.5(206.9)	7.6	663.0(201.8)	7.6	11.3(3.4)	0.6
2014	678.3(203.0)	7.4	675.4(206.7)	7.6	663.0(201.4)	7.6	12.2(3.7)	0.6
2015	682.7(203.8)	7.4	679.7(207.5)	7.6	666.9(202.1)	7.6	12.7(3.8)	0.6
2016	687.2(204.7)	7.5	684.0(208.4)	7.7	670.2(202.8)	7.7	13.7(4.1)	0.6
2017	693.5(206.1)	7.5	690.1(209.8)	7.8	675.5(204.1)	7.8	14.5(4.4)	0.7
2018	695.9(206.4)	7.6	692.5(210.1)	7.8	677.6(204.4)	7.8	14.8(4.5)	0.7
2019	698.5(206.9)	7.6	695.2(210.6)	7.9	679.4(204.8)	7.8	15.8(4.8)	0.7
2020	701.1(207.3)	7.7	697.9(211.1)	7.9	681.2(205.2)	7.9	16.6(5.0)	0.7
2021	701.0(206.9)	7.7	697.7(210.7)	7.9	680.0(204.7)	7.9	17.6(5.3)	0.8
2022	697.6(205.7)	7.7	694.4(209.4)	7.9	675.8(203.4)	7.9	18.5(5.6)	0.8
2023	695.3(204.8)	7.6	692.1(208.5)	7.9	672.9(202.5)	7.9	19.2(5.8)	0.8
2024	694.4(204.3)	7.6	691.2(208.0)	7.9	671.3(202.1)	7.8	19.8(5.9)	0.8
2025	693.1(203.7)	7.7	690.1(207.4)	7.9	669.8(201.8)	7.9	20.1(6.1)	0.8
				Strictly protected forests (commercial felling is prohibited)				
2008	66.6(20.3)	2.9	66.5(20.7)	2.9	66.1(20.4)	2.9	0.3(0.1)	0.1
2009	67.2(20.4)	2.9	67.1(20.8)	2.9	66.7(20.5)	2.9	0.3(0.1)	0.1
2010	68.2(20.6)	2.9	68.1(21.1)	3.0	67.7(20.8)	3.0	0.3(0.1)	0.1
2011	69.5(21.0)	3.0	69.4(21.4)	3.0	69.0(21.1)	3.0	0.3(0.1)	0.1
2012	71.3(21.5)	3.0	71.2(21.9)	3.1	70.8(21.6)	3.1	0.3(0.1)	0.1
2013	72.2(21.7)	3.1	72.1(22.1)	3.1	71.7(21.8)	3.1	0.3(0.1)	0.1
2014	73.1(21.9)	3.1	73.0(22.3)	3.2	72.5(22.0)	3.2	0.4(0.1)	0.1
2015	74.0(22.1)	3.1	73.8(22.5)	3.2	73.3(22.2)	3.2	0.4(0.1)	0.1
2016	75.3(22.4)	3.2	75.2(22.9)	3.3	74.7(22.6)	3.2	0.4(0.1)	0.1
2017	76.8(22.8)	3.3	76.7(23.3)	3.3	76.1(23.0)	3.3	0.4(0.1)	0.1
2018	77.7(23.0)	3.3	77.5(23.5)	3.4	77.0(23.2)	3.3	0.4(0.1)	0.1
2019	78.7(23.3)	3.3	78.6(23.8)	3.4	78.0(23.5)	3.4	0.4(0.1)	0.1
2020	79.7(23.6)	3.4	79.5(24.1)	3.4	79.0(23.8)	3.4	0.4(0.1)	0.1
2021	80.3(23.7)	3.4	80.0(24.2)	3.5	79.5(23.9)	3.5	0.4(0.1)	0.1
2022	81.2(23.9)	3.5	80.9(24.4)	3.5	80.4(24.2)	3.5	0.4(0.1)	0.1
2023	81.5(24.0)	3.5	81.2(24.5)	3.5	80.8(24.3)	3.5	0.4(0.1)	0.1
2024	82.0(24.1)	3.5	81.7(24.6)	3.5	81.2(24.5)	3.5	0.4(0.1)	0.1
2025	82.9(24.4)	3.5	82.6(24.8)	3.6	82.1(24.7)	3.6	0.5(0.1)	0.1

Table 4. The estimated mean (± standard error, *SE*) annual changes in growing stock (increment, felling, and mortality) in forests of Latvia during the latest three forest inventory cycles (2010–2024). Forests in their entirety and protected forests are presented. The numbers in brackets show the mean volume per area of forests (m^3 ha^{-1})

	2015		2020		2025	
	Volume	*SE*	Volume	*SE*	Volume	*SE*
All forests						
Annual increment, M m^3	27.3(8.3)	0.3	26.7(8.1)	0.3	24.6(7.4)	0.3
Annual felled volume, M m^3	16.7(5.1)	0.6	18.1(5.5)	0.6	19.9(6.0)	0.7
Annual mortality, M m^3	6.1(1.9)	0.1	5.4(1.6)	0.1	6.0(1.8)	0.2
Net difference, M m^3	4.5(1.4)	0.6	3.2(1.0)	0.7	–1.4(–0.4)	–0.7
Strictly protected forests (commercial felling is prohibited)						
Annual increment, M m^3	2.3(0.7)	0.1	2.1(0.6)	0.1	1.9(0.6)	0.1
Annual felled volume, M m^3	0.2(0.1)	0.1	0.1(0.1)	0.0	0.2(0.1)	0.1
Annual mortality, M m^3	0.8(0.2)	0.1	0.8(0.2)	0.1	1.0(0.3)	0.1
Net difference, M m^3	1.3(0.4)	0.1	1.2(0.4)	0.1	0.7(0.2)	0.1

last 10 years (Table 4), which can explain the stabilisation of the national total net values. At the same time, estimated annual felling volumes increased by 3.33 million m^3 per year (0.94 m^3 per year per hectare compared to 2025) over the same period (Figure 2); however, annual felling volumes fluctuated significantly, exceeding the uncertainties (Figure 2). Such a pattern can be explained by the increased demand for timber/energy wood during the last inventory cycles, particularly due to recent geopolitical processes in Europe (Jonsson and Sotirov 2025). This highlighted the strategic importance of local timber resources.

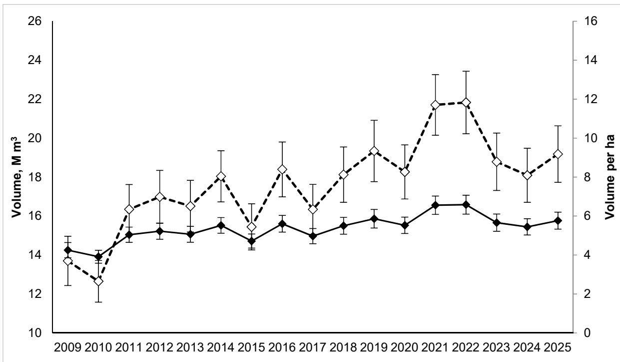

Figure 2. The annual rolling five-year mean (± standard error, *SE*) amount of felled growing stock (dashed line; primary axis) and its reflection per forest area (solid line, secondary axis) in forest land of Latvia during the period 2009–2025. Last year of the respective period is shown

Nevertheless, felling combined with steady mortality (Figure 3) has resulted in an effectively zero net difference, hence likely approached an equilibrium of growing stock. In the protected forests, mortality has been increasing, likely as trees age, and sanitary measures have not been implemented. Although ever-increasing growing stock would be desirable for carbon sequestration (Wernick and Kauppi 2022, Pardos et al. 2025), realistic growth predictions imply stabilisation when the environmental capacity, which includes all components of ecosystems (i.e. anthropogenic), is reached (Kauppi et al. 2022, Fan et al. 2023, Dye et al. 2024). From a management perspective, balanced growth and utilisation of local timber resources is desirable, indicating predictable resource flow (Pili et al. 2022, Raihan 2023, Jonsson and Sotirov 2025). Nevertheless, efforts should be made to maintain such a balance whilst simultaneously ensuring multifunctionality of forests, e.g. other non-timber ecosystem services (Nagel et al. 2025, Nirhamo et al. 2025).

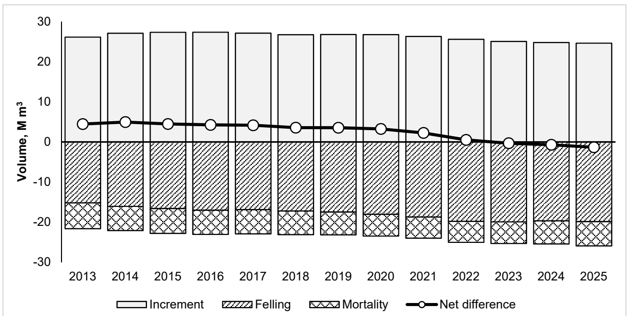

Figure 3. The ten-year rolling mean increment, natural mortality, and felling, as well as the net balance of growing stock (by volume) in forests of Latvia during the period 2013–2025. The last year of the respective ten-year interval is shown. The forest area in Latvia is 3,318.3 kha

Vegetation models predict explicit reductions in abundance and, therefore, in the standing volume of conifers in the Baltic countries, particularly in Latvia (Buras and Menzel 2019, Mauri et al. 2022). Such changes have already been evident in the dynamics of standing volume estimates by species (Table 5), and the distribution by species resembled that by forest area. Such changes were similar in all forests regardless of protection status. Among the most common species, Scots pine, grey alder, and common ash showed decreasing trends, yet the trend has remained within the uncertainty. In contrast, other species showed an increasing trend, which exceeded the uncertainty for Norway spruce, European aspen, pedunculate oak, Norway maple, and willows. These species have been considered important for biodiversity in stands in the hemiboreal region (Leidinger et al. 2021), thus supporting non-timber ecosystem services (Felton et al. 2024).

Since the late 1990s, Latvia has adopted a retention forest management practice with a mandate to retain at least

Table 5. Mean estimated (± standard error, *SE*) growing stock by species (in M m^3 and m^3 ha^{-1} in brackets) during the period covered by the national forest inventory in forests of Latvia

Species	2006–2010		2011–2015		2016–2020		2021–2025	
	Volume	*SE*	Volume	*SE*	Volume	*SE*	Volume	*SE*
All forests								
Pine (*Pinus sylvestris*)	196.6(60.9)	3.9	195.8(59.9)	3.9	195.6(59.3)	4.0	190.9(57.5)	4.0
Spruce (*Picea abies*)	161.6(50.1)	2.9	169.1(51.7)	3.1	180(54.6)	3.3	174.9(52.7)	3.2
Birches (*Betula* spp.)	144.6(44.8)	2.5	147.2(45.1)	2.6	151.2(45.9)	2.7	149.9(45.2)	2.7
Aspen (*Populus tremula*)	50.4(15.6)	2.0	53.4(16.4)	2.1	55.5(16.8)	2.2	57.5(17.3)	2.2
Black alder (*Alnus glutinosa*)	36.2(11.2)	1.4	39.6(12.1)	1.6	42.1(12.8)	1.7	43.8(13.2)	1.7
Grey alder (*Alnus incana*)	41.5(12.9)	1.4	43(13.1)	1.4	40(12.1)	1.3	38.4(11.6)	1.3
Oak (*Quercus robur*)	7.7(2.4)	0.5	8.5(2.6)	0.5	9.7(2.9)	0.6	10.7(3.2)	0.7
Willows (*Salix* spp.)	6.9(2.2)	0.3	7.9(2.4)	0.4	8.7(2.6)	0.4	8.2(2.5)	0.4
Maple (*Acer platanoides*)	2.2(0.7)	0.2	3.2(1)	0.3	4(1.2)	0.3	5(1.5)	0.4
Lime (*Tilia cordata*)	3.3(1)	0.3	3.7(1.1)	0.4	4.1(1.3)	0.4	4.4(1.3)	0.4
Ash (*Fraxinus excelsior*)	6.2(1.9)	0.5	4.5(1.4)	0.4	3.1(0.9)	0.3	2.4(0.7)	0.2
Elms (*Ulmus* spp.)	1.7(0.5)	0.2	2.1(0.6)	0.2	2.2(0.7)	0.2	2.1(0.6)	0.2
European larch (*Larix decidua*)	0.3(0.1)	0.1	0.4(0.1)	0.1	0.4(0.1)	0.2	0.5(0.1)	0.2
Other species	0.9(0.3)	0.1	1.2(0.4)	0.1	1.3(0.4)	0.1	1.3(0.4)	0.1
Strictly protected forests (commercial felling is prohibited)								
Pine (*Pinus sylvestris*)	26.1(8.1)	1.5	28.3(8.7)	1.7	30.4(9.2)	1.8	32.2(9.7)	1.9
Spruce (*Picea abies*)	13.5(4.2)	0.9	15(4.6)	1.0	16.8(5.1)	1.1	17.3(5.2)	1.1
Birches (*Betula* spp.)	14.5(4.5)	0.9	15.4(4.7)	1.0	16.2(4.9)	1.0	16.2(4.9)	1.0
Aspen (*Populus tremula*)	5(1.6)	0.7	5.5(1.7)	0.8	6(1.8)	0.9	6.3(1.9)	0.9
Black alder (*Alnus glutinosa*)	4.5(1.4)	0.5	5(1.5)	0.6	5.6(1.7)	0.6	6.2(1.9)	0.7
Grey alder (*Alnus incana*)	1(0.3)	0.2	0.9(0.3)	0.2	0.9(0.3)	0.2	0.8(0.2)	0.2
Oak (*Quercus robur*)	0.8(0.3)	0.2	0.9(0.3)	0.3	1(0.3)	0.3	1(0.3)	0.3
Willows (*Salix* spp.)	0.3(0.1)	0.1	0.3(0.1)	0.1	0.3(0.1)	0.1	0.3(0.1)	0.1
Maple (*Acer platanoides*)	0.3(0.1)	0.1	0.3(0.1)	0.1	0.4(0.1)	0.1	0.5(0.1)	0.1
Lime (*Tilia cordata*)	0.5(0.2)	0.1	0.8(0.2)	0.2	0.9(0.3)	0.2	0.9(0.3)	0.2
Ash (*Fraxinus excelsior*)	1.2(0.4)	0.3	0.9(0.3)	0.2	0.6(0.2)	0.2	0.3(0.1)	0.1
Elms (*Ulmus* spp.)	0.4(0.1)	0.1	0.5(0.1)	0.1	0.4(0.1)	0.1	0.4(0.1)	0.1
European larch (*Larix decidua*)	0(0)	0.0	0(0)	0.0	0(0)	0.0	0(0)	0.0
Other species	0.1(0)	0.0	0.1(0)	0.0	0.1(0)	0.0	0.1(0)	0.0

Table 6. Changes in mean estimated (± standard error, *SE*) volume of deadwood by type (in M m^3) for the five years covered by the national forest inventory in forests of Latvia

Deadwood group	Volume (M m^3)				Mean volume (m^3 ha^{-1})			
	2004–2008		2021–2025		2004–2008		2021–2025	
	Volume	*SE*	Volume	*SE*	Volume	*SE*	Volume	*SE*
Lying deadwood ≤ 10.0 cm	2.7	0.1	3.1	0.1	0.9	0.0	0.9	0.0
Lying deadwood 10.1–20.0 cm	12.2	0.3	11.5	0.3	3.8	0.1	3.5	0.1
Lying deadwood 20.1–30.0 cm	10.5	0.3	10.6	0.3	3.3	0.1	3.2	0.1
Lying deadwood > 30.0 cm	9.2	0.4	15.2	0.6	2.8	0.1	4.6	0.2
Lying deadwood total	34.7	0.7	40.3	0.9	10.7	0.2	12.2	0.3
Standing deadwood ≤ 10.0 cm	2.7	0.1	2.3	0.1	0.8	0.0	0.7	0.0
Standing deadwood 10.1–20.0 cm	8.4	0.2	6.3	0.2	2.6	0.1	1.9	0.0
Standing deadwood 20.1–30.0 cm	6.2	0.2	6.8	0.2	1.9	0.1	2.0	0.1
Standing deadwood > 30.0 cm	5.5	0.3	8.6	0.5	1.7	0.1	2.6	0.1
Standing deadwood total	22.8	0.5	24.1	0.7	7.1	0.2	7.3	0.2
All deadwood ≤ 10.0 cm	5.5	0.1	5.4	0.1	1.7	0.0	1.6	0.0
All deadwood 10.1–20.0 cm	20.6	0.4	17.8	0.4	6.4	0.1	5.4	0.1
All deadwood 20.1–30.0 cm	16.7	0.4	17.4	0.4	5.2	0.1	5.2	0.1
All deadwood > 30.0 cm	14.7	0.6	23.8	0.9	4.5	0.2	7.2	0.3
Deadwood in total	57.5	1.1	64.4	1.3	17.8	0.3	19.4	0.4

5 trees per ha for biodiversity conservation (Girdziušas et al. 2021), whilst forestry companies implemented semi-voluntary retention to comply with certification requirements (Lehtonen et al. 2021). Accordingly, the standing volume of the retention trees, which are currently represented in groups, steadily increases, nearly tripling the volume and more than doubling the share during the course of surveys from 2004 to 2025. Given that retention trees efficiently maintain their functionality in terms of microhabitats (Gerra-Inohosa et al. 2023, Jansone et al. 2023), this increase suggests rising efficiency of biodiversity conservation efforts in intensively managed forest stands, which comprise most of the forests (Girdziušas et al. 2021, Lehtonen et al. 2021). In turn, this supports the TRIAD concept (Himes

et al. 2022, Nagel et al. 2025), as one of the economically viable solutions for implementing actions required by the EU Nature Restoration Law (Regulation 2024/1991) without shattering the wood-related industry and hampering the national economy.

The amount of deadwood, particularly when distinguished between standing and lying, which is a biodiversity metric considered by the EU Nature Restoration Law, has shown some increase with stabilisation during the recent three inventory cycles (Table 6). According to the latest inventory cycle (2020–2024), the total amount of deadwood was estimated as approx. 64.4 M m^3, translating as 19.4 ± 0.4 m^3 ha^{-1}, which notably exceeds the European mean value (Puletti et al. 2019). Still, the estimate appears underestimated due to the exclusion of strongly/completely decayed deadwood. The ratio of lying to standing deadwood was 1.68 to 1, which translates to 12.2 ± 0.3 and 7.3 ± 0.2 m^3 ha^{-1}, respectively. The temporal changes were mostly related to the amounts of lying deadwood, which likely reflect the legacy of recent disturbances, such as the 2005 storm, ash dieback, and spruce dieback due to bark beetle infestation (Donis et al. 2018, Potterf et al. 2025). Regarding the dimensions, most of the deadwood was represented by logs of moderate and large size (> 10 cm), with the large-sized deadwood (> 20 cm) accounting for a similar share of the total volume as the smaller-diameter classes. Still, it must be admitted that the NFI is underestimating the total amount of deadwood, as finer deadwood, branches, and stumps were not accounted for.

Conclusions

The forest area and volume of growing stock, as well as the volume of deadwood in Latvia, have steadily increased, exceeding the uncertainty during the period 2004–2025. Since Latvia is located in the hemiboreal zone, coniferous and deciduous trees make up approximately equal shares of the growing stock and forest area, with the number of deciduous trees increasing. Logging volumes fluctuated but increased in line with demand for timber and energy wood, driven by global processes and regional geopolitical situations. Changes in national regulation, apparently, did not notably alter the amount of felling. However, the net increase in growing stock indicates a dynamic equilibrium, as the increment was comparable to natural mortality and cutting, and some excess increment was recorded at the beginning of the reporting period.

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