ANNEX 3

Complementary document to the results of the Serbian Second National Forest Inventory

**-Recalculation of the NFI2 report using the Two-phase Sampling design-**

**Project: GCP/SRB/002/GFF: Contribution of sustainable forest management to a low emission and resilient development in Serbia (FSP)**

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# Background

The Food and Agriculture Organization (FAO) has partnered with the government of Serbia to implement the project GCP/SRB/002/GFF, “Contribution of Sustainable Forest Management to Low Emission and Resilient Development,” which has been approved by the Global Environmental Fund. The report of this mission is part of the overall implementation of this project.

According to the Forest Resources Assessment*[[1]](#footnote-1)*, Serbia is covered by forests, with an area of 2,722,218.84 hectares, accounting for approximately 31.1% of the country’s total land. The forest sector contributed 1.3% to the national GDP in 2019*[[2]](#footnote-2)*, including the value added by forestry and logging and the manufacture of wood and wood products. Over 1,498,000 hectares of forests are used for productive purposes. Regarding ownership, 53% of the forests are owned by the state, while the rest are privately owned.

The location of forests in hilly or mountainous regions poses challenges for effective forest management. Despite these challenges, Serbian forests are rich in genetic, species, and ecosystem diversity. The forests and shrublands featuring endemic woody plants are significant.

Serbia’s most significant environmental impacts are deforestation, forest degradation, and biodiversity loss where illegal logging, forest fires, and impacts from the agriculture are the major drivers of this impacts.

Serbia's current national forest policy lacks quantified targets and specific guidance on forest carbon management and biodiversity conservation. There is a lack of comprehensive information management systems and limited capacities among institutions responsible for sustainable forest management. The project “Contribution of Sustainable Forest Management to a Low Emission and Resilient Development”[[3]](#footnote-3) aims to address these barriers and promote sustainable forest management by improving information systems, bringing 80,000 hectares of forests under sustainable management, and incorporating multi-sectoral priorities, including carbon sequestration and biodiversity conservation.

Under Component 1 of the project “Enabling Environment for Multifunctional Sustainable Forest Management,” an Integrated Forest Information System was established to provide users with easy access to information for both strategic and operational purposes. Output 1, “Methodology for Forest and Biodiversity Information Collection and Management,” has introduced a novel approach for data collection and analysis.

As part of Output 1, FAO supports Serbia in implementing a new National Forest Inventory Sampling Design, utilizing a two-phase sampling method. The first phase involves an analysis of land cover of all sampling points using a 1km x 1km grid. This information was collected using visual interpretation of high-resolution free imagery available on the Google Earth and Bing platforms using the FAO - Collect Earth (CE) tool[[4]](#footnote-4), and its results were used as a post-stratification variable for the second sampling phase.

The first phase of data collection had also included historical records of the land cover changes in Serbia, from the year 2000 to 2018. For this historical analysis, IPCC land cover classes were used: Cropland, Forest, Grassland, Other land, Settlement, and Wetland. It is essential to highlight that the IPCC classes differ from the land cover classes used in the Forest Resources Assessment (FRA) 2020.

# About this report

The project GCP/SRB/002/GFF “Contribution of Sustainable Forest Management to a Low Emission and Resilient Development”[[5]](#footnote-5), has proposed a new national forest inventory methodology to be implemented in the Republic of Serbia.

The methodology of the new approach, is fully described in Pantic, Dees and Borota (2020).[[6]](#footnote-6)

FAO (2023)[[7]](#footnote-7) present the major results of the National Forest Inventory in Serbia, however, for the calculation of those results, sampling approach defined for the project (two phase sampling design), was not implemented. For this report, the simple random analysis was implemented, but any of the statistical inferences was calculated or included using this sampling design.

In this report, all the calculated tables in FAO (2023), are recalculated using the original sampling design defined at the beginning of the project.

# Two-phase sampling approach in a National Forest Inventory

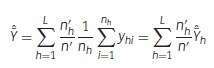
The availability and accessibility of high-resolution spatial information have increased in recent years, leading to a growing tendency to use such information in national forest inventories. In this context, the two-stage sampling design has become essential in the new designs of national forest inventories (Ramírez et al. 2022).

In this design, the first sampling phase focuses on land cover analysis, using high-resolution imagery, LiDAR, or radar. With this information, it is easy to define the different strata for phase 2 for the field data collection. At the same time, it can provide accurate and detailed information on forest area and forest type (Tomppo et al., 2008). This process is efficient because it can be largely automated. In the second phase, a sample is selected from the preliminary sample using a more intensive and accurate measurement method, such as systematic sampling, which involves laying out a grid of sample points or transects and measuring all the trees or vegetation within a fixed distance or area.

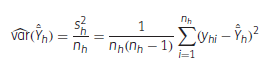
An optimal national forest inventory aims to obtain estimates of forest extension and structure that meet specified precision goals for the least cost (Köhl et al., 2011). When applying a two-phase sampling design, the uncertainty statistical variables are obtained using a specific method to calculate the data variance. According to Mandallaz (2008), the mean value of any variable within a stratum (Ῡh) may be estimated by the sample mean of all phase-two points within that stratum (nh).

Ejemplo de imagen

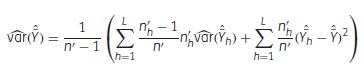
The estimated mean volume over all strata is then given by:



where L is the number of strata, n’ is the total number of phase-one points and n’h is the number of phases one points within stratum h. The variance of the estimated mean within a stratum is estimated by:



and the variance of the estimated overall mean, according to the infinite population approach (Saborowski et al., 2010), by:



The two-phase sampling design has several advantages over other sampling designs. It is more efficient, cost-effective, and less time-consuming. It also provides more accurate and detailed information on forest area and forest type, which is essential for observing and managing critical environmental and socioeconomic trends. In addition, the design allows for early alerts and prompt assessments in case of impacts for wildfires and pests and diseases, among others.

The two-phase sampling design is an essential tool for sustainable forest management, as it helps optimize resource use and mitigate the effects of climate change.

The statistical indicators for the two-phase sampling design were assessed in the Serbian Second National Forest Inventory (NFI). Phase 1 plots are all plots of each cluster at grid 1km x 1km, and phase 2 plots are all the plots of each cluster at grid 4km x 4km.

The “forest inventory”[[8]](#footnote-8) package for R software was used to apply the “two-phase” function to obtain the statistical estimators for the area of the land cover types. For each level of the land use variable (each type of land cover defined in the Serbian NFI), it was necessary to create a “dummy” variable. This variable type can be defined as D = 1 for forest plots and/or clusters and D = 0 for the remaining land cover types. Such dummy variables divide the sample into an equal number of new variables (or sub-populations) as the land use types registered in the land use variable of the NFI.

All the procedures for the calculation are summarized in annex 1, where the .Rmd file can be imported and run in R Studio.

# Assembling the complete data set for the data processing

For data collection and analysis, the software OSNOVA was selected for the project, as it was used in the previous national forest inventory, and it is well known in Serbia.

All the information is collected using digital devices that export the data to the OSNOVA Server.

For the preliminary report, FAO (2023) has used the OSNOVA software to produce the report. However, for the analysis with the new sampling design methodology, the information was exported into Microsoft Access data tables.

The OSNOVA software is a commercial one, with special license, and it is recommended to use some open-source platform to store the NFI2 data securely and permanently to ensure the accessibility of the data.

Once the data tables with the NFI2 data have been clean up and validated (Q/A), the data is imported into R Studio for further analysis. All the procedure are explained steps by step at the Annex 4, that includes the rmd file that can be open in R Studio.

The NFI2 of Serbia was conducted with two sampling phases. The first phase involves an analysis on land cover of all sampling points using a 1km x 1km grid. This information was conducted using the FAO Collect Earth (CE) tool[[9]](#footnote-9) and it’s results were used as a post stratification variable for the second phase of sampling.

This second phase used a 4km x 4km sampling grid to sample forest structure variables in forest-related land use covers. In order to have the information on land cover and forest structure variables, it was necessary to join both sources of information in the same table to allow performing the statistical analyses corresponding to a two-phase sampling with post-stratification design.

To properly estimate the proportion of Forest area together with another post stratification variable (as ownership, stand origin, naturalness, etc.) an extra estimate defined as the ratio of the corresponding two-phase estimates needs to be produced in order to be able to present the improved two-phase estimates of total forest area partitioned by the used post stratification variable with the corresponding estimates of shares of the variable categories on total forest area.

As this statistical procedure is not available under R forest inventory package, it’s necessary to apply the following function that was prepared by Adolt (2023)[[10]](#footnote-10). This function (fn\_two\_phase\_ratio\_estimator) needs to be run in advance of the statistical estimator’s determination of post stratification variables used in the NFI of Serbia.

fn\_two\_phase\_ratio\_estimator <- function(nominator, denominator)   
{  
 t1 <- (nominator$estimation)$estimate  
 t2<- (denominator$estimation)$estimate  
 R12 <- t1/t2  
   
 u <- nominator$Rc\_x\_hat - denominator$mean\_Rc\_x\_hat\*R12  
 nominator\_variable <-   
 substring(toString(nominator$input$formula),  
 gregexpr(" " , toString(nominator$input$formula))[[1]][1]+1,  
 gregexpr(", " , toString(nominator$input$formula))[[1]][2]-1)   
   
 nominator\_variable\_index <-   
 match(nominator\_variable, names(nominator$input$data))   
   
 denominator\_variable <-   
 substring(toString(denominator$input$formula),  
 gregexpr(" " , toString(denominator$input$formula))[[1]][1]+1,  
 gregexpr(", " , toString(denominator$input$formula))[[1]][2]-1)   
   
 denominator\_variable\_index <-   
 match(denominator\_variable, names(denominator$input$data))   
   
 nominator2phase\_data <-   
 nominator$input$data[nominator$input$data$phase==2,]  
   
 denominator2phase\_data <-   
 denominator$input$data[denominator$input$data$phase==2,]  
   
 y1 <- nominator2phase\_data[, nominator\_variable\_index]  
 y2 <- denominator2phase\_data[, denominator\_variable\_index]  
 cluster <- nominator2phase\_data$cluster  
   
 sum\_y1\_per\_cluster <- aggregate(y1, by=list(cluster=cluster), sum)[,2]  
 sum\_y2\_per\_cluster <- aggregate(y2, by=list(cluster=cluster), sum)[,2]  
 nplots\_per\_cluster <- aggregate(y2, by=list(cluster=cluster), length)[,2]  
   
 y1c <- sum\_y1\_per\_cluster / nplots\_per\_cluster  
 y2c <- sum\_y2\_per\_cluster / nplots\_per\_cluster  
   
 n1 <- (nominator$estimation)$n1  
 n2 <- (nominator$estimation)$n2  
   
 v1 <- 1 / t2^2 \* (1 - n2/n1) / n2 / (n2-1) / mean(nplots\_per\_cluster)^2 \*   
 sum(nplots\_per\_cluster^2 \* (u - sum(u\*nplots\_per\_cluster) /   
 sum(nplots\_per\_cluster))^2)  
   
 v2 <- 1 / t2^2 / n1 / (n2 - 1) / mean(nplots\_per\_cluster)^2 \*  
 sum(nplots\_per\_cluster^2 \* (y1c - R12\*y2c)^2)  
   
 return (list(R12 = R12, var = v1 + v2, stderr = sqrt(v1 + v2)))  
}

# Two-phase sampling poststratification results

For each post stratification variable, it was needed to create the dummy variables as an indicator of the proportion of forest plots by cluster that correspond to each level of the variable that will be analyzed.

As part of data preparation, to apply the two-phase method, it was also needed to add analogous variables that indicates the correct values of the numerical variables (number of trees, total volume and total volume increment) that can describe the structural characteristics using the correct proportion of plots in the clusters that suits the forest for each level of the post stratification variable.

## Forest by Ownership

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_ownership | % | SE\_% | ha | SE\_ha |  |
| State | 41.73 | 0.13 | 1191466.32 | 10475.57 |  |
| Private | 58.27 | 0.15 | 1663489.43 | 10445.07 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_ownership | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| State | 1175450042.82 | 37657413.16 | 983.52 | 29.66 | 36.69 |
| Private | 2028106784.90 | 46950125.75 | 1215.43 | 26.51 | 63.31 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100 |
| VOLUME | | | | | |
| Stand\_ownership | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| State | 280102417.98 | 9103750.57 | 234.37 | 7.10 | 50.29 |
| Private | 276868738.60 | 6513069.81 | 165.93 | 3.67 | 49.71 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100 |
| VOLUME INCREMENT | | | | | |
| Stand\_ownership | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| State | 6636160.20 | 204107.34 | 5.55 | 0.16 | 46.31 |
| Private | 7693341.08 | 167303.86 | 4.61 | 0.09 | 53.69 |
| Total | 14329501.29 | 194610.73 | 5.00 | 0.06 | 100 |

## Forest by Stand origin

In the following table the results for forest area, number of trees, wood volume and volume increment according to stand origin post stratification variable are presented for the categories of natural high stands, natural coppice stands and artificially established stands. All the rest of the plots at each cluster label as inaccessible points, shrub associations, bush-land or NA levels for stand origin are grouped together as “ori\_NA” to facilitate the results comparison with the NFI2 report.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_origin | % | SE\_% | ha | SE\_ha |  |
| Natural high stands | 25.82 | 0.11 | 737257.20 | 8625.43 |  |
| Natural coppice stands | 65.17 | 0.15 | 1860597.90 | 9719.90 |  |
| Artificially established stands | 7.47 | 0.06 | 213283.13 | 4916.49 |  |
| ori\_NA | 1.53 | 0.03 | 43817.53 | 2817.96 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_origin | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| Natural high stands | 529357216.16 | 21124135.70 | 715.80 | 26.95 | 16.52 |
| Natural coppice stands | 2325992760.10 | 49015214.72 | 1246.28 | 24.60 | 72.61 |
| Artificially established stands | 204634693.96 | 15549114.50 | 956.50 | 68.68 | 6.39 |
| ori\_NA | 143572157.50 | 11800377.42 | 3266.50 | 295.95 | 4.48 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100.00 |
| VOLUME | | | | | |
| Stand\_origin | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| Natural high stands | 232843833.48 | 8856476.23 | 314.85 | 11.12 | 41.81 |
| Natural coppice stands | 270989012.84 | 5698873.68 | 145.20 | 2.86 | 48.65 |
| Artificially established stands | 46079951.44 | 3374376.97 | 215.39 | 14.87 | 8.27 |
| ori\_NA | 7058358.82 | 517055.85 | 160.59 | 13.51 | 1.27 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100.00 |
| VOLUME INCREMENT | | | | | |
| Stand\_origin | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| Natural high stands | 4514632.56 | 166760.65 | 6.10 | 0.21 | 31.51 |
| Natural coppice stands | 7902715.74 | 155477.76 | 4.23 | 0.08 | 55.15 |
| Artificially established stands | 1634166.58 | 124126.46 | 7.64 | 0.55 | 11.40 |
| ori\_NA | 277986.4128 | 20077.9463 | 6.3246401 | 0.523934 | 1.94 |
| Total | 14329501.29 | 194610.731 | 5.0037061 | 0.062688 | 100 |

## Forest by Naturalness

The following table shows information on forest area, number of trees, wood volume and volume increment according to stand naturalness post stratification variable are presented for the categories of forest without anthropogenic interventions, plantation, semi-natural forests. All the rest of the plots at each cluster label as inaccessible points or NA are grouped together as “nat\_NA” to facilitate the results comparison with the NFI2 report.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_naturalness | % | SE\_% | ha | SE\_ha |  |
| Forest without anthropogenic interventions | 0.81 | 0.02 | 23228.22 | 1947.12 |  |
| Plantation | 6.59 | 0.06 | 188246.36 | 4583.40 |  |
| Semi-natural forests | 91.05 | 0.17 | 2599444.55 | 8270.00 |  |
| nat\_NA | 1.54 | 0.03 | 44036.63 | 2817.96 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_naturalness | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| Forest without anthropogenic interventions | 20783274.43 | 5761097.47 | 891.92 | 233.23 | 0.65 |
| Plantations | 189103102.95 | 15091295.34 | 1001.38 | 75.52 | 5.90 |
| Semi-natural forests | 2906217662.97 | 46997209.99 | 1114.48 | 16.87 | 90.72 |
| nat\_NA | 87452787.38 | 8886792.19 | 1989.69 | 216.27 | 2.73 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100.00 |
| VOLUME | | | | | |
| Stand\_naturalness | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| Forest without anthropogenic interventions | 5427203.18 | 1811487.13 | 232.91 | 73.07 | 0.97 |
| Plantations | 41185911.30 | 3131392.65 | 218.10 | 15.64 | 7.39 |
| Semi-natural forests | 505004896.44 | 8680839.17 | 193.66 | 3.09 | 90.67 |
| nat\_NA | 5353145.65 | 471213.24 | 121.79 | 11.89 | 0.96 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100.00 |
| VOLUME INCREMENT | | | | | |
| Stand\_naturalness | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| Forest without anthropogenic interventions | 111366.75 | 34876.36 | 4.78 | 1.41 | 0.78 |
| Plantations | 1496434.98 | 120529.49 | 7.92 | 0.60 | 10.44 |
| Semi-natural forests | 12513699.19 | 179429.68 | 4.80 | 0.06 | 87.33 |
| nat\_NA | 208000.37 | 17989.35 | 4.73 | 0.45 | 1.45 |
| Total | 14329501.29 | 194610.73 | 5.00 | 0.06 | 100.00 |

## Forest by Stand preservation status

The following table shows the forest area, number of trees, wood volume and volume increment according to stand preservation status post stratification variable are presented for each level of this variable. All the plots at each cluster label as inaccessible points or NA are grouped together as “pre\_NA” to facilitate the results comparison with the NFI2 report.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_preservation | % | SE\_% | ha | SE\_ha |  |
| conserved stand | 57.07 | 0.15 | 1629294.49 | 8447.76 |  |
| devastated stand | 11.79 | 0.07 | 336702.40 | 4842.22 |  |
| thinned stand | 29.59 | 0.11 | 844922.24 | 6934.68 |  |
| pre\_NA | 1.54 | 0.03 | 44036.63 | 2817.96 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_preservation | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| conserved stand | 2116361606.52 | 43308864.45 | 1294.84 | 24.85 | 66.06 |
| devastated stand | 349751835.60 | 19424324.05 | 1035.48 | 54.61 | 10.92 |
| thinned stands | 658984786.63 | 22775498.14 | 777.47 | 25.55 | 20.57 |
| pre\_NA | 78458598.96 | 8494834.52 | 1785.06 | 205.22 | 2.45 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100.00 |
| VOLUME | | | | | |
| Stand\_preservation | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| conserved stand | 403287694.31 | 8338359.03 | 246.74 | 4.74 | 72.41 |
| devastated stand | 30685045.92 | 1730636.65 | 90.85 | 4.88 | 5.51 |
| thinned stands | 117917187.92 | 4022406.31 | 139.12 | 4.47 | 21.17 |
| pre\_NA | 5081228.44 | 464428.55 | 115.61 | 11.65 | 0.91 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100.00 |
| VOLUME INCREMENT | | | | | |
| Stand\_preservation | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| conserved stand | 10584961.97 | 201348.56 | 6.48 | 0.11 | 73.87 |
| devastated stand | 758569.19 | 36687.70 | 2.25 | 0.10 | 5.29 |
| thinned stands | 2789007.75 | 82662.95 | 3.29 | 0.09 | 19.46 |
| pre\_NA | 196962.38 | 17704.27 | 4.48 | 0.44 | 1.37 |
| Total | 14329501.29 | 194610.73 | 5.00 | 0.06 | 100.00 |

## Forest by Stand mixture

The following table depicts the results for forest area, number of trees, wood volume and volume increment according to stand mixture. The forest of Serbia is classified as “mixed broadleaf and coniferous stand”, “mixed broadleaf stand”, “mixed coniferous stand”, “pure broadleaf stand” and “pure coniferous stand”. All the plots at each cluster label as inaccessible points or NA are grouped together as “mix\_NA” to facilitate the results comparison with the NFI2 report.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_mixture | % | SE\_% | ha | SE\_ha |  |
| mixed broadleaf and coniferous | 3.25 | 0.04 | 92881.10 | 3139.73 |  |
| mixed broadleaf | 42.31 | 0.13 | 1207956.68 | 8274.69 |  |
| mixed coniferous | 0.85 | 0.02 | 24341.51 | 1479.21 |  |
| pure broadleaf | 44.98 | 0.13 | 1284055.67 | 8513.58 |  |
| pure coniferous | 7.06 | 0.06 | 201684.17 | 4942.83 |  |
| mix\_NA | 1.54 | 0.03 | 44036.63 | 2817.96 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_mixture | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| mixed broadleaf and coniferous | 92634281.69 | 10146154.38 | 994.19 | 102.43 | 2.89 |
| mixed broadleaf | 1505012875.97 | 40522131.05 | 1241.98 | 31.38 | 46.98 |
| mixed coniferous | 21348483.72 | 4463960.94 | 874.27 | 172.39 | 0.67 |
| pure broadleaved | 1297150785.44 | 33027089.10 | 1007.01 | 24.37 | 40.49 |
| pure coniferous | 199957613.52 | 15673499.71 | 988.31 | 73.30 | 6.24 |
| mix\_NA | 87452787.38 | 8886792.19 | 1989.69 | 216.27 | 2.73 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100.00 |
| VOLUME | | | | | |
| Stand\_mixture | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| mixed broadleaf and coniferous | 25323165.86 | 3062925.06 | 271.78 | 30.67 | 4.55 |
| mixed broadleaf | 178769481.23 | 4534195.02 | 147.53 | 3.51 | 32.10 |
| mixed coniferous | 8043084.85 | 1771504.69 | 329.38 | 67.69 | 1.44 |
| pure broadleaf | 287114501.51 | 7874269.18 | 222.89 | 5.72 | 51.55 |
| pure coniferous | 52367777.47 | 4315660.90 | 258.83 | 20.01 | 9.40 |
| mix\_NA | 5353145.65 | 471213.24 | 121.79 | 11.89 | 0.96 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100.00 |
| VOLUME INCREMENT | | | | | |
| Stand\_mixture | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| mixed broadleaf and coniferous | 585053.62 | 64623.94 | 6.28 | 0.65 | 4.08 |
| mixed broadleaf | 5268491.91 | 130015.90 | 4.35 | 0.10 | 36.77 |
| mixed coniferous | 183357.77 | 37777.08 | 7.51 | 1.44 | 1.28 |
| pure broadleaf | 6665880.15 | 166225.07 | 5.17 | 0.12 | 46.52 |
| pure coniferous | 1418717.46 | 108103.69 | 7.01 | 0.50 | 9.90 |
| mix\_NA | 208000.37 | 17989.35 | 4.73 | 0.45 | 1.45 |
| Total | 14329501.29 | 194610.73 | 5.00 | 0.06 | 100.00 |

## Forest by Stand category

The following tables shows the results for forest area, number of trees, wood volume and volume increment according to stand category. All the plots at each cluster label as inaccessible points or NA are grouped together as “cat\_NA” to facilitate the results comparison with the NFI2 report. Although bushy formations are not included in the NFI2 report, there were cluster with data for this stand category, so we include the results and the statistical estimations.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_category | % | SE\_% | ha | SE\_ha |  |
| Alder forests | 0.55 | 0.02 | 15603.12 | 1024.63 |  |
| Artificially planted stands | 7.46 | 0.06 | 212863.63 | 4910.35 |  |
| Ash and maple forests | 0.77 | 0.02 | 21892.49 | 1161.28 |  |
| Beech forests | 25.68 | 0.11 | 733042.83 | 8505.47 |  |
| Birch, aspen and acacia forests | 11.72 | 0.07 | 334531.30 | 5193.50 |  |
| Bushy formations | 0.00 | 0.00 | 0.00 | 0.00 |  |
| Common Oak forests | 0.96 | 0.02 | 27344.34 | 2017.48 |  |
| Downy oak forests | 1.27 | 0.02 | 36199.60 | 1867.20 |  |
| Fir forests | 1.15 | 0.02 | 32899.46 | 2273.16 |  |
| Flowering Ash,Oriental Hornbeam and Hornbeam | 7.04 | 0.06 | 200889.73 | 3883.24 |  |
| Hornbeam forests | 5.26 | 0.05 | 150103.89 | 3192.59 |  |
| Hungarian oak forests | 5.82 | 0.05 | 166179.09 | 3920.70 |  |
| Linden forests | 1.45 | 0.03 | 41320.08 | 1983.84 |  |
| Narrow-leaf ash forests | 1.14 | 0.02 | 32619.12 | 1836.63 |  |
| Pine forests | 1.81 | 0.03 | 51755.05 | 2687.81 |  |
| Poplar forests | 0.60 | 0.02 | 17031.89 | 1057.55 |  |
| Sessile Oak forests | 7.84 | 0.06 | 223692.46 | 4650.45 |  |
| Spruce forests | 2.26 | 0.03 | 64532.41 | 3103.90 |  |
| Turkey oak forests | 15.00 | 0.08 | 428124.03 | 5920.24 |  |
| Willow forest | 0.71 | 0.02 | 20294.60 | 1137.35 |  |
| cat\_NA | 1.54 | 0.03 | 44036.63 | 2817.96 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_category | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| Alder forests | 12455686.17 | 2994473.77 | 795.76 | 183.68 | 0.39 |
| Artificially planted stands | 204610394.39 | 15548544.85 | 958.19 | 68.81 | 6.39 |
| Ash and maple forests | 19063361.54 | 3557231.06 | 868.02 | 153.52 | 0.60 |
| Beech forests | 581468052.67 | 23297962.55 | 790.72 | 29.90 | 18.15 |
| Birch, aspen and acacia forests | 439559387.77 | 23458912.19 | 1309.81 | 66.51 | 13.72 |
| Bushy formations | 7729788.62 | 1665885.03 | Inf | NA | 0.24 |
| Common Oak forests | 14739385.86 | 3090174.55 | 537.33 | 105.65 | 0.46 |
| Downy oak forests | 56480926.81 | 10648355.17 | 1555.34 | 275.74 | 1.76 |
| Fir forests | 28119820.06 | 5952608.68 | 852.02 | 168.79 | 0.88 |
| Flowering Ash,Oriental Hornbeam and Hornbeam | 359396261.22 | 24358661.84 | 1783.37 | 114.35 | 11.22 |
| Hornbeam forests | 219439244.26 | 16754179.25 | 1457.30 | 105.11 | 6.85 |
| Hungarian oak forests | 210177867.01 | 15736700.55 | 1260.77 | 88.76 | 6.56 |
| Linden forests | 44509757.18 | 7071334.79 | 1073.79 | 163.35 | 1.39 |
| Narrow-leaf ash forests | 29613068.86 | 5469754.17 | 904.98 | 160.33 | 0.92 |
| Pine forests | 49234293.64 | 8594524.56 | 948.29 | 157.91 | 1.54 |
| Poplar forests | 8678424.28 | 2184832.63 | 507.93 | 122.30 | 0.27 |
| Sessile Oak forests | 267882845.93 | 18466502.92 | 1193.77 | 77.30 | 8.36 |
| Spruce forests | 50060731.99 | 7716928.27 | 773.30 | 112.91 | 1.56 |
| Turkey oak forests | 506749707.27 | 22931861.51 | 1179.91 | 50.23 | 15.82 |
| Willow forest | 15129223.24 | 3374618.74 | 743.13 | 161.39 | 0.47 |
| cat\_NA | 78458598.96 | 8494834.52 | 1785.06 | 205.22 | 2.45 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100 |
| VOLUME | | | | | |
| Stand\_category | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| Alder forests | 2156888.55 | 439402.09 | 137.80 | 26.62 | 0.39 |
| Artificially planted stands | 46068109.92 | 3373995.18 | 215.74 | 14.90 | 8.27 |
| Ash and maple forests | 3848504.97 | 724034.66 | 175.24 | 30.92 | 0.69 |
| Beech forests | 213211327.73 | 7989351.25 | 289.94 | 10.11 | 38.28 |
| Birch, aspen and acacia forests | 26594708.65 | 1527567.02 | 79.25 | 4.32 | 4.77 |
| Bushy formations | 401227.27 | 79834.31 | Inf | NA | 0.07 |
| Common Oak forests | 9812186.62 | 2242419.90 | 357.70 | 75.96 | 1.76 |
| Downy oak forests | 3018732.23 | 523921.26 | 83.13 | 13.55 | 0.54 |
| Fir forests | 14755913.25 | 2919953.80 | 447.10 | 82.06 | 2.65 |
| Flowering Ash,Oriental Hornbeam and Hornbeam | 16422359.24 | 1066085.76 | 81.49 | 5.02 | 2.95 |
| Hornbeam forests | 19624335.15 | 1361525.16 | 130.33 | 8.51 | 3.52 |
| Hungarian oak forests | 27221413.43 | 1961792.25 | 163.29 | 11.07 | 4.89 |
| Linden forests | 8655226.62 | 1404548.05 | 208.81 | 31.63 | 1.55 |
| Narrow-leaf ash forests | 8289944.98 | 1724959.61 | 253.34 | 49.50 | 1.49 |
| Pine forests | 8430541.15 | 1548350.12 | 162.38 | 27.96 | 1.51 |
| Poplar forests | 3346049.59 | 672445.91 | 195.84 | 38.04 | 0.60 |
| Sessile Oak forests | 36102430.01 | 2359183.22 | 160.88 | 9.86 | 6.48 |
| Spruce forests | 22867380.98 | 3502004.66 | 353.24 | 50.45 | 4.11 |
| Turkey oak forests | 78472483.76 | 3576124.90 | 182.71 | 7.85 | 14.09 |
| Willow forest | 2590164.03 | 508987.15 | 127.23 | 24.07 | 0.47 |
| cat\_NA | 5081228.44 | 464428.55 | 115.61 | 11.65 | 0.91 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100 |
| VOLUME INCREMENT | | | | | |
| Stand\_category | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| Alder forests | 75440.14 | 15382.93 | 4.82 | 0.94 | 0.53 |
| Artificially planted stands | 1633809.90 | 124117.86 | 7.65 | 0.55 | 11.40 |
| Ash and maple forests | 106740.78 | 20469.14 | 4.86 | 0.88 | 0.74 |
| Beech forests | 4403206.81 | 158255.23 | 5.99 | 0.20 | 30.73 |
| Birch, aspen and acacia forests | 1195813.78 | 66102.15 | 3.56 | 0.19 | 8.35 |
| Bushy formations | 13447.00 | 2741.38 | Inf | NA | 0.09 |
| Common Oak forests | 142856.91 | 29708.86 | 5.21 | 1.01 | 1.00 |
| Downy oak forests | 113064.15 | 23509.42 | 3.11 | 0.61 | 0.79 |
| Fir forests | 276182.16 | 53849.15 | 8.37 | 1.52 | 1.93 |
| Flowering Ash,Oriental Hornbeam and Hornbeam | 633732.74 | 41833.84 | 3.14 | 0.20 | 4.42 |
| Hornbeam forests | 667019.63 | 47251.66 | 4.43 | 0.30 | 4.65 |
| Hungarian oak forests | 661009.90 | 47556.42 | 3.97 | 0.27 | 4.61 |
| Linden forests | 304166.68 | 51244.83 | 7.34 | 1.15 | 2.12 |
| Narrow-leaf ash forests | 196090.83 | 33482.99 | 5.99 | 0.96 | 1.37 |
| Pine forests | 209985.28 | 36420.44 | 4.04 | 0.66 | 1.47 |
| Poplar forests | 101090.23 | 20674.98 | 5.92 | 1.17 | 0.71 |
| Sessile Oak forests | 916268.02 | 57841.38 | 4.08 | 0.24 | 6.39 |
| Spruce forests | 493614.73 | 71910.57 | 7.62 | 1.04 | 3.44 |
| Turkey oak forests | 1904689.13 | 82880.56 | 4.43 | 0.18 | 13.29 |
| Willow forest | 84310.10 | 17445.34 | 4.14 | 0.83 | 0.59 |
| cat\_NA | 196962.38 | 17704.27 | 4.48 | 0.44 | 1.37 |
| Total | 14329501.29 | 194610.73 | 5.00 | 0.06 | 100 |

## Forest by Stand structural form

The following table shows the results for forest area, number of trees, wood volume and volume increment according to stand structure. All the plots at each cluster label as inaccessible points or NA are grouped together as “struc\_NA” to facilitate the results comparison with the NFI2 report.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_structure | % | SE\_% | ha | SE\_ha |  |
| even-aged stands | 92.22 | 0.17 | 2632785.39 | 8194.99 |  |
| selection stand | 0.72 | 0.02 | 20447.83 | 1875.05 |  |
| uneven-aged stand | 5.52 | 0.05 | 157685.91 | 4272.67 |  |
| struc\_NA | 1.54 | 0.03 | 44036.63 | 2817.96 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_structure | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| even-aged stands | 2993651542.90 | 48037901.10 | 1133.48 | 17.01 | 93.45 |
| selection stand | 16361440.31 | 4005438.75 | 797.63 | 183.06 | 0.51 |
| uneven-aged stand | 106091057.14 | 9103741.55 | 670.68 | 53.86 | 3.31 |
| struc\_NA | 87452787.38 | 8886792.19 | 1989.69 | 216.27 | 2.73 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100.00 |
| VOLUME | | | | | |
| Stand\_structure | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| even-aged stands | 484819527.65 | 7912916.91 | 183.57 | 2.78 | 87.05 |
| selection stand | 9806018.58 | 2528155.30 | 478.05 | 114.08 | 1.76 |
| uneven-aged stand | 56992464.69 | 4587488.80 | 360.29 | 26.95 | 10.23 |
| struc\_NA | 5353145.65 | 471213.24 | 121.79 | 11.89 | 0.96 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100.00 |
| VOLUME INCREMENT | | | | | |
| Stand\_structure | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| even-aged stands | 12882651.02 | 190294.20 | 4.88 | 0.07 | 89.90 |
| selection stand | 175184.20 | 43507.57 | 8.54 | 1.96 | 1.22 |
| uneven-aged stand | 1063665.69 | 85803.93 | 6.72 | 0.50 | 7.42 |
| struc\_NA | 208000.37 | 17989.35 | 4.73 | 0.45 | 1.45 |
| Total | 14329501.29 | 194610.73 | 5.00 | 0.06 | 100.00 |

## Forest by age class

The following tables shows the results for forest area, number of trees, wood volume and volume increment according to stand age class. All the plots at each cluster label as inaccessible points or NA are grouped together as “age\_NA” to facilitate the results comparison with the NFI2 report.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_ageclass | % | SE\_% | ha | SE\_ha |  |
| I age class (poorly covered) | 4.23 | 0.04 | 120673.96 | 2757.27 |  |
| I age class (well covered) | 3.16 | 0.04 | 90097.07 | 2491.02 |  |
| II age class | 7.41 | 0.06 | 211414.32 | 3834.68 |  |
| III age class | 10.86 | 0.07 | 309991.79 | 4434.86 |  |
| IV age class | 15.30 | 0.08 | 436879.50 | 5091.09 |  |
| V age class | 14.99 | 0.08 | 427854.61 | 4899.79 |  |
| VI age class | 12.96 | 0.08 | 369931.82 | 4779.99 |  |
| VII age class | 9.12 | 0.06 | 260281.67 | 3978.08 |  |
| VIII age class | 13.87 | 0.08 | 396075.14 | 5375.89 |  |
| IX regenerated surface with standards | 0.17 | 0.01 | 4983.84 | 683.14 |  |
| X surface in the regeneration process | 0.13 | 0.01 | 3767.66 | 511.65 |  |
| age\_NA | 7.81 | 0.06 | 223004.38 | 5442.86 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_ageclass | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| I age class (poorly covered) | 37199420.17 | 5059278.10 | 307.19 | 41.28 | 1.16 |
| I age class (well covered) | 64696486.88 | 8810255.43 | 715.58 | 94.06 | 2.02 |
| II age class | 273003816.43 | 18101102.87 | 1286.84 | 81.43 | 8.52 |
| III age class | 410937267.30 | 20922089.39 | 1321.03 | 63.79 | 12.83 |
| IV age class | 601056502.10 | 26013237.18 | 1371.02 | 55.91 | 18.76 |
| V age class | 510154018.31 | 21154069.56 | 1188.21 | 46.63 | 15.92 |
| VI age class | 426383707.42 | 20463793.09 | 1148.60 | 52.30 | 13.31 |
| VII age class | 264085453.95 | 13788560.45 | 1011.09 | 49.90 | 8.24 |
| VIII age class | 346373466.88 | 16522516.20 | 871.48 | 39.08 | 10.81 |
| IX regenerated surface with standards | 2410339.25 | 1625101.20 | 481.95 | 308.10 | 0.08 |
| X surface in the regeneration process | 1231694.09 | 725955.73 | 325.78 | 179.61 | 0.04 |
| age\_NA | 266024654.95 | 15578204.07 | 1194.81 | 68.29 | 8.30 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100.00 |
| VOLUME | | | | | |
| Stand\_ageclass | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| I age class (poorly covered) | 1778937.46 | 220490.74 | 14.69 | 1.77 | 0.32 |
| I age class (well covered) | 2420599.14 | 327926.22 | 26.77 | 3.48 | 0.43 |
| II age class | 15250552.10 | 1162967.63 | 71.89 | 5.25 | 2.74 |
| III age class | 39520821.88 | 2234867.50 | 127.05 | 6.80 | 7.10 |
| IV age class | 77951093.75 | 3499357.36 | 177.81 | 7.51 | 14.00 |
| V age class | 82785807.51 | 3367167.56 | 192.82 | 7.37 | 14.86 |
| VI age class | 86290788.01 | 3856187.99 | 232.45 | 9.73 | 15.49 |
| VII age class | 65587588.95 | 3459350.05 | 251.11 | 12.41 | 11.78 |
| VIII age class | 108955235.44 | 4702629.14 | 274.13 | 11.10 | 19.56 |
| IX regenerated surface with standards | 1227971.62 | 513014.12 | 245.53 | 96.25 | 0.22 |
| X surface in the regeneration process | 1344918.63 | 620911.24 | 355.72 | 152.75 | 0.24 |
| age\_NA | 73856842.10 | 5399131.40 | 331.72 | 22.71 | 13.26 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100.00 |
| VOLUME INCREMENT | | | | | |
| Stand\_ageclass | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| I age class (poorly covered) | 62427.95 | 8075.76 | 0.52 | 0.07 | 0.44 |
| I age class (well covered) | 106244.70 | 14142.77 | 1.18 | 0.15 | 0.74 |
| II age class | 635376.17 | 45745.48 | 2.99 | 0.21 | 4.43 |
| III age class | 1386629.51 | 72423.34 | 4.46 | 0.22 | 9.68 |
| IV age class | 2479584.17 | 105004.15 | 5.66 | 0.23 | 17.30 |
| V age class | 2272476.63 | 85876.38 | 5.29 | 0.19 | 15.86 |
| VI age class | 2101432.78 | 86391.76 | 5.66 | 0.22 | 14.67 |
| VII age class | 1531825.95 | 78301.59 | 5.86 | 0.28 | 10.69 |
| VIII age class | 2204211.67 | 99495.15 | 5.55 | 0.24 | 15.38 |
| IX regenerated surface with standards | 14492.02 | 6473.81 | 2.90 | 1.22 | 0.10 |
| X surface in the regeneration process | 17963.45 | 8421.59 | 4.75 | 2.07 | 0.13 |
| age\_NA | 1516836.30 | 100998.92 | 6.81 | 0.43 | 10.59 |
| Total | 14329501.29 | 194610.73 | 5.00 | 0.06 | 100.00 |

## Forest by stand canopy condition

The following table shows the results for forest area, number of trees, wood volume and volume increment according to stand canopy. All the plots at each cluster label as inaccessible points or NA are grouped together as “canopy\_NA” to facilitate the results comparison with the NFI2 report.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_canopy | % | SE\_% | ha | SE\_ha |  |
| complete canopy (0,6-0,8) | 49.20 | 0.14 | 1404511.47 | 8250.53 |  |
| dense canopy (0,8-1,0) | 7.87 | 0.06 | 224797.51 | 4219.37 |  |
| incomplete canopy (0,4-0,6) | 29.60 | 0.11 | 844929.75 | 6934.68 |  |
| scattered canopy (< 0,4) | 11.79 | 0.07 | 336705.40 | 4842.22 |  |
| not\_determine | 0.18 | 0.01 | 5001.35 | 997.20 |  |
| canopy\_NA | 1.37 | 0.03 | 39010.27 | 2640.59 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_canopy | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| complete canopy (0,6-0,8) | 1759295055.80 | 40155228.01 | 1248.66 | 26.74 | 54.92 |
| dense canopy (0,8-1,0) | 357066550.72 | 21809813.72 | 1583.39 | 91.65 | 11.15 |
| incomplete canopy (0,4-0,6) | 658984786.63 | 22775498.14 | 777.47 | 25.55 | 20.57 |
| scattered canopy (< 0,4) | 340757647.19 | 19173170.66 | 1008.85 | 53.88 | 10.64 |
| not\_determine | 14460270.47 | 3198734.18 | 2882.17 | 720.70 | 0.45 |
| canopy\_NA | 72992516.91 | 8315896.50 | 1874.69 | 227.04 | 2.28 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100.00 |
| VOLUME | | | | | |
| Stand\_canopy | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| complete canopy (0,6-0,8) | 341834820.36 | 7674230.29 | 242.62 | 5.07 | 61.37 |
| dense canopy (0,8-1,0) | 61452873.94 | 3885603.79 | 272.51 | 16.14 | 11.03 |
| incomplete canopy (0,4-0,6) | 117917187.92 | 4022406.31 | 139.12 | 4.47 | 21.17 |
| scattered canopy (< 0,4) | 30413128.70 | 1728775.88 | 90.04 | 4.87 | 5.46 |
| not\_determine | 637043.51 | 153128.35 | 126.97 | 34.26 | 0.11 |
| canopy\_NA | 4716102.14 | 446849.29 | 121.13 | 12.71 | 0.85 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100.00 |
| VOLUME INCREMENT | | | | | |
| Stand\_canopy | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| complete canopy (0,6-0,8) | 8796406.79 | 179543.60 | 6.24 | 0.12 | 61.39 |
| dense canopy (0,8-1,0) | 1788555.18 | 110900.38 | 7.93 | 0.46 | 12.48 |
| incomplete canopy (0,4-0,6) | 2789007.75 | 82662.95 | 3.29 | 0.09 | 19.46 |
| scattered canopy (< 0,4) | 747531.20 | 36511.53 | 2.21 | 0.10 | 5.22 |
| not\_determine | 23764.75 | 5074.79 | 4.74 | 1.15 | 0.17 |
| canopy\_NA | 184235.62 | 17305.40 | 4.73 | 0.49 | 1.29 |
| Total | 14329501.29 | 194610.73 | 5.00 | 0.06 | 100.00 |

## Forest by stand silvicultural treatment

The following table shows the results for forest area, number of trees, wood volume and volume increment according to stand silvicultural treatment. All the plots at each cluster label as inaccessible points or NA are grouped together as “silvi\_NA” to facilitate the results comparison with the NFI2 report.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
| Stand\_silviculturalTreat | % | SE\_% | ha | SE\_ha |  |
| cleaning | 1.01 | 0.02 | 28733.39 | 1474.63 |  |
| clear cutting | 5.51 | 0.05 | 157390.75 | 3539.31 |  |
| conversion | 4.49 | 0.05 | 128076.35 | 3019.12 |  |
| no interventions | 45.61 | 0.13 | 1302005.46 | 8402.91 |  |
| regeneration cutting in even-aged stands | 5.19 | 0.05 | 148102.05 | 3717.67 |  |
| regeneration cutting in uneven-aged forests | 3.36 | 0.04 | 95798.84 | 3183.20 |  |
| regeneration with site preparation | 1.21 | 0.02 | 34484.83 | 1636.25 |  |
| regeneration without site preparation | 1.72 | 0.03 | 49101.77 | 2044.63 |  |
| selection cutting | 0.99 | 0.02 | 28340.75 | 2110.66 |  |
| supplementary planting | 0.28 | 0.01 | 7924.70 | 883.51 |  |
| thinning | 29.11 | 0.11 | 830960.24 | 7176.30 |  |
| silvi\_NA | 1.54 | 0.03 | 44036.63 | 2817.96 |  |
| Total | 100.00 |  | 2854955.75 |  |  |
| NUMBER OF TREES | | | | | |
| Stand\_silviculturalTreat | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| cleaning | 33285617.46 | 7425053.65 | 1154.77 | 245.24 | 1.04 |
| clear cutting | 183427933.45 | 14087330.55 | 1161.75 | 84.79 | 5.73 |
| conversion | 106450105.28 | 8158432.22 | 828.52 | 59.98 | 3.32 |
| no interventions | 1484349082.92 | 41009303.56 | 1136.45 | 29.74 | 46.33 |
| regeneration cutting in even-aged stands | 76040264.11 | 6280888.80 | 511.81 | 39.69 | 2.37 |
| regeneration cutting in uneven-aged forests | 60757224.26 | 6402387.48 | 632.21 | 62.34 | 1.90 |
| regeneration with site preparation | 17271245.98 | 3495536.06 | 499.25 | 97.04 | 0.54 |
| regeneration without site preparation | 38490742.67 | 6311376.86 | 781.42 | 120.72 | 1.20 |
| selection cutting | 25148955.14 | 5487365.04 | 884.58 | 180.70 | 0.79 |
| supplementary planting | 743365.09 | 290809.63 | 93.51 | 34.85 | 0.02 |
| thinning | 1104599774.47 | 32295176.99 | 1325.11 | 36.29 | 34.48 |
| silvi\_NA | 72992516.91 | 8315896.50 | 1660.70 | 199.69 | 2.28 |
| Total | 3203556827.72 | 47579700.36 | 1118.65 | 15.58 | 100.0 |
| VOLUME | | | | | |
| Stand\_silviculturalTreat | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| cleaning | 1674177.17 | 358155.54 | 58.08 | 11.82 | 0.30 |
| clear cutting | 27645001.47 | 2254647.75 | 175.09 | 13.50 | 4.96 |
| conversion | 40894411.28 | 2880835.06 | 318.29 | 21.07 | 7.34 |
| no interventions | 141248703.01 | 3943162.77 | 108.14 | 2.84 | 25.36 |
| regeneration cutting in even-aged stands | 58194086.65 | 4270949.08 | 391.69 | 26.73 | 10.45 |
| regeneration cutting in uneven-aged forests | 39063499.79 | 3657091.40 | 406.48 | 35.36 | 7.01 |
| regeneration with site preparation | 3701307.39 | 592889.47 | 106.99 | 16.37 | 0.66 |
| regeneration without site preparation | 6563188.96 | 1105134.05 | 133.24 | 21.42 | 1.18 |
| selection cutting | 13303959.44 | 2865995.36 | 467.95 | 93.35 | 2.39 |
| supplementary planting | 143872.71 | 60010.72 | 18.10 | 7.24 | 0.03 |
| thinning | 219822846.57 | 6165594.57 | 263.71 | 6.89 | 39.47 |
| silvi\_NA | 4716102.14 | 446849.29 | 107.30 | 11.15 | 0.85 |
| Total | 556971156.58 | 8755026.14 | 194.49 | 2.84 | 100.0 |
| VOLUME INCREMENT | | | | | |
| Stand\_silviculturalTreat | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| cleaning | 76987.04 | 17776.91 | 2.67 | 0.59 | 0.54 |
| clear cutting | 1039214.04 | 88655.10 | 6.58 | 0.53 | 7.25 |
| conversion | 748475.77 | 52139.05 | 5.83 | 0.38 | 5.22 |
| no interventions | 4362375.54 | 111752.11 | 3.34 | 0.08 | 30.44 |
| regeneration cutting in even-aged stands | 901440.56 | 65777.54 | 6.07 | 0.41 | 6.29 |
| regeneration cutting in uneven-aged forests | 680424.76 | 64804.35 | 7.08 | 0.63 | 4.75 |
| regeneration with site preparation | 74790.41 | 11848.74 | 2.16 | 0.33 | 0.52 |
| regeneration without site preparation | 115143.20 | 16756.49 | 2.34 | 0.32 | 0.80 |
| selection cutting | 249744.29 | 52664.91 | 8.78 | 1.72 | 1.74 |
| supplementary planting | 3288.09 | 1245.69 | 0.41 | 0.15 | 0.02 |
| thinning | 5893381.96 | 160679.98 | 7.07 | 0.18 | 41.13 |
| silvi\_NA | 184235.62 | 17305.40 | 4.19 | 0.43 | 1.29 |
| Total | 14329501.29 | 194610.73 | 5.00 | 0.06 | 100.0 |

## Forest stocks of Biomass and carbon

A relevant objective of the NFI2 is the meticulous analysis and computation of both above and below-ground biomass as well as carbon stocks. The quantification of living tree biomass was achieved through the utilization of volume expansion factors coupled with the fresh wood density of respective species. Conversely, estimating the biomass stock of standing dead trees involved the application of expansion factors and dry wood density. Unfortunately, the estimation of biomass stock for fallen logs proved unattainable, given the absence of data on decomposition stages or specific wood densities. Additionally, a comprehensive assessment of biomass and carbon for stumps was conducted. The determination of total biomass and carbon stocks involved aggregating the individual stocks within each plot and subsequently calculating the average for each cluster.

The ensuing table delineates the outcomes pertaining to the total biomass and carbon for the forest, as well as the Old Woodland (OWL) and Other Land with Tree Cover (OLWTC) categories. It is important to note that the percentage related to Trees outside the forest could not be computed. This limitation arises from the unavailability of this variable at both sampling phases within the Land Use category.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AREA | | | | |  |
|  | % | SE\_% | ha | SE\_ha |  |
| Forest | 36.81 | 0.17 | 2854955.75 | 18767.65 |  |
| Other Wooded land (OWL) | 2.20 | 0.05 | 170515.72 | 10499.00 |  |
| Other Land With Trees Cover (OLWTC) | 4.15 | 0.07 | 321804.81 | 8129.99 |  |
| TOTAL BIOMASS | | | | | |
| Stand\_biomass | t | SE\_t | t/ha | SE\_t/ha | % |
| Forests | 511169127.08 | 8196634.30 | 178.49 | 2.65 | 99.09 |
| Other wooded land | 2483668.66 | 316123.43 | 14.52 | 3.07 | 0.48 |
| Other land with tree cover | 2220118.68 | 229491.96 | 6.88 | 1.24 | 0.43 |
| TOTAL CARBON | | | | | |
| Stand\_carbon | t | SE\_t | t/ha | SE\_t/ha | % |
| Forests | 255584563.54 | 4098317.15 | 89.25 | 1.33 | 99.09 |
| Other wooded land | 1241834.33 | 158061.71 | 7.26 | 1.53 | 0.48 |
| Other land with tree cover | 1110059.34 | 114745.98 | 3.44 | 0.62 | 0.43 |

## Forest by tree species

The following table shows the results concerning forest area, number of trees, wood volume, and volume increment for each documented species within the forest clusters. Notably, all species within a cluster labeled as NA have been amalgamated under the designation "spp\_NA." Additionally, certain species codes eluded precise attribution to corresponding scientific or common nomenclature. To circumvent the loss of such information, the results for these species are denoted as "spp."

The mean values presented in the table below serve as indicators of the anticipated number of trees, volume, or volume increment per hectare specific to the areas where each species is recorded within the forest. This distinction ensures a focused representation, offering insights into the characteristics of each species within its respective habitat.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NUMBER OF TREES | | | | | |
| Specie | kom | SE\_kom | kom/ha | SE\_kom/ha | % |
| beech | 522127828.13 | 13788962.03 | 814.75 | 27.64 | 16.2984 |
| black locust | 343971699.70 | 11920024.02 | 1039.85 | 44.13 | 10.7372 |
| hornbeam | 332997044.65 | 10132532.96 | 777.69 | 35.41 | 10.3946 |
| Turkey oak | 269031977.78 | 7242618.01 | 427.31 | 15.74 | 8.3979 |
| oriental hornbeam | 250612449.29 | 11825803.41 | 2160.91 | 141.21 | 7.8229 |
| flowering ash | 233788607.51 | 8044541.45 | 750.07 | 37.29 | 7.2978 |
| sessile oak | 160255411.55 | 6150689.81 | 429.81 | 21.85 | 5.0024 |
| Hungarian oak | 158186361.01 | 6552523.21 | 542.30 | 27.84 | 4.9378 |
| other broadleaf (OB) | 114173053.09 | 5039123.57 | 490.70 | 35.35 | 3.5639 |
| black pine | 100496805.81 | 6636571.54 | 786.28 | 56.41 | 3.1370 |
| field maple | 84861361.41 | 3324787.26 | 325.31 | 19.24 | 2.6490 |
| spruce | 73491926.13 | 5250250.65 | 704.91 | 60.19 | 2.2941 |
| cherry | 59362894.73 | 2752733.48 | 289.37 | 20.70 | 1.8530 |
| ssp | 42425751.56 | 2772964.86 | 392.13 | 38.53 | 1.3243 |
| european aspen | 41067254.53 | 3083143.59 | 482.53 | 51.77 | 1.2819 |
| field elm | 38125083.66 | 2337063.84 | 404.39 | 34.76 | 1.1901 |
| Scots pine | 36776904.35 | 3900434.04 | 539.74 | 75.28 | 1.1480 |
| pubescent oak | 34410156.47 | 2939734.45 | 570.51 | 57.94 | 1.0741 |
| European hop hornbeam | 26718198.14 | 2973258.32 | 753.10 | 112.39 | 0.8340 |
| fir | 25291767.95 | 3030100.87 | 630.59 | 92.12 | 0.7895 |
| large-leaf lime | 24223792.51 | 2822725.12 | 448.11 | 79.48 | 0.7562 |
| silver lime | 22846023.58 | 2123030.33 | 416.06 | 49.86 | 0.7131 |
| narrow-leaf ash | 19799389.94 | 2027636.15 | 358.14 | 52.36 | 0.6180 |
| silver birch | 17833546.22 | 1808117.83 | 355.62 | 50.59 | 0.5567 |
| white willow | 13650024.96 | 1886237.96 | 466.21 | 98.02 | 0.4261 |
| domestic nut | 13297943.66 | 1358199.38 | 275.96 | 46.57 | 0.4151 |
| maple | 13212948.73 | 1166893.30 | 196.81 | 26.53 | 0.4124 |
| ssp\_NA | 11998919.94 | 1213377.83 | 68.04 | 11.79 | 0.3745 |
| European white elm | 11739223.57 | 1875064.76 | 439.13 | 106.53 | 0.3664 |
| black alder | 11322819.06 | 2294692.16 | 564.28 | 185.67 | 0.3534 |
| chequer tree | 10512462.35 | 868610.84 | 208.74 | 27.51 | 0.3281 |
| boxelder | 10370136.81 | 1305547.83 | 534.97 | 95.63 | 0.3237 |
| EA poplar | 9384154.36 | 1010501.72 | 311.83 | 28.98 | 0.2929 |
| pedunculate oak | 8897476.54 | 1211384.49 | 231.50 | 42.16 | 0.2777 |
| European ash | 8785599.94 | 991223.38 | 244.22 | 40.98 | 0.2742 |
| american ash | 8769948.54 | 1732689.24 | 672.72 | 168.81 | 0.2738 |
| white poplar | 5329441.42 | 1034760.09 | 295.55 | 87.45 | 0.1664 |
| tree of heaven | 5069477.31 | 1382638.43 | 899.48 | 366.67 | 0.1582 |
| norway maple | 4992906.04 | 655460.98 | 192.66 | 34.95 | 0.1559 |
| white alder | 3055849.15 | 923236.46 | 508.08 | 231.49 | 0.0954 |
| small-leaf lime | 2846748.25 | 477494.54 | 191.67 | 41.98 | 0.0889 |
| European Nettle Tree | 2814936.14 | 614823.28 | 360.34 | 64.28 | 0.0879 |
| turkish hazel | 2645349.54 | 355477.54 | 162.68 | 30.59 | 0.0826 |
| black walnut | 1921917.25 | 688903.36 | 627.26 | 254.40 | 0.0600 |
| rowan | 1894881.45 | 461458.79 | 396.65 | 134.38 | 0.0591 |
| mountain elm | 1538282.10 | 181444.60 | 99.84 | 18.23 | 0.0480 |
| eastern white pine | 1473104.36 | 475106.82 | 850.90 | 281.56 | 0.0460 |
| black poplar | 1276964.30 | 211623.44 | 99.73 | 20.57 | 0.0399 |
| Siberian elm | 842151.24 | 219611.56 | 250.92 | 88.05 | 0.0263 |
| honey locust | 665600.34 | 220628.88 | 343.26 | 116.26 | 0.0208 |
| larch | 657171.76 | 284861.25 | 655.39 | 541.96 | 0.0205 |
| Douglas fir | 615559.66 | 179254.77 | 350.12 | 126.15 | 0.0192 |
| grey willow | 390243.44 | 135299.69 | 188.49 | 71.54 | 0.0122 |
| brittle willow | 320922.60 | 130793.27 | 175.38 | 116.72 | 0.0100 |
| mountain maple | 185815.72 | 55996.50 | 130.92 | 50.29 | 0.0058 |
| Chinese scholar tree | 95085.78 | 39315.71 | 136.94 | 21.27 | 0.0030 |
| chestnut | 67974.53 | 33719.20 | 85.84 | 35.36 | 0.0021 |
| grey poplar | 26331.44 | 15451.66 | Inf | NA | 0.0008 |
| oriental plane | 13165.72 | 7724.14 | 55.66 | 41.66 | 0.0004 |
| VOLUME | | | | | |
|  | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| beech | 204295593.01 | 5272476.74 | 317.69 | 8.71 | 36.6797 |
| Turkey oak | 73047532.51 | 1694662.19 | 115.62 | 3.64 | 13.1151 |
| sessile oak | 32062038.23 | 1017794.25 | 85.69 | 3.49 | 5.7565 |
| spruce | 31850070.81 | 2360018.45 | 304.44 | 21.72 | 5.7184 |
| Hungarian oak | 26172894.69 | 908690.81 | 89.42 | 3.78 | 4.6991 |
| hornbeam | 25644386.90 | 672502.49 | 59.68 | 2.11 | 4.6043 |
| black pine | 21243663.26 | 1239504.98 | 165.63 | 11.06 | 3.8141 |
| black locust | 19709537.32 | 681989.05 | 59.38 | 2.64 | 3.5387 |
| fir | 11611498.17 | 1274944.49 | 288.50 | 36.41 | 2.0848 |
| pedunculate oak | 11342685.48 | 1269572.74 | 294.10 | 31.41 | 2.0365 |
| flowering ash | 9290667.96 | 292378.90 | 29.70 | 1.29 | 1.6681 |
| narrow-leaf ash | 8826546.45 | 864793.77 | 159.11 | 17.95 | 1.5847 |
| EA poplar | 8150536.46 | 921368.39 | 269.90 | 30.80 | 1.4634 |
| Scots pine | 6636479.10 | 604053.46 | 97.06 | 10.29 | 1.1915 |
| oriental hornbeam | 6062504.70 | 279937.73 | 52.09 | 3.26 | 1.0885 |
| other broadleaf (OB) | 5780221.19 | 206318.57 | 24.76 | 1.41 | 1.0378 |
| european aspen | 4791727.83 | 304538.11 | 56.11 | 4.90 | 0.8603 |
| cherry | 4749600.26 | 168339.83 | 23.07 | 1.20 | 0.8528 |
| silver lime | 4258458.42 | 437552.04 | 77.28 | 9.44 | 0.7646 |
| large-leaf lime | 3857262.90 | 323236.04 | 71.11 | 7.68 | 0.6925 |
| maple | 3153620.68 | 245155.67 | 46.81 | 4.84 | 0.5662 |
| white willow | 2925901.78 | 305634.53 | 99.59 | 13.05 | 0.5253 |
| pubescent oak | 2872886.85 | 215255.45 | 47.47 | 3.66 | 0.5158 |
| European hop hornbeam | 2339191.35 | 241718.41 | 65.71 | 7.63 | 0.4200 |
| field elm | 2309312.29 | 128247.75 | 24.41 | 1.76 | 0.4146 |
| silver birch | 2149979.11 | 173840.74 | 42.72 | 4.37 | 0.3860 |
| white poplar | 2143799.86 | 272968.76 | 118.47 | 17.95 | 0.3849 |
| ssp | 2075222.76 | 93118.91 | 19.11 | 1.20 | 0.3726 |
| European ash | 2062101.72 | 182213.17 | 57.12 | 6.48 | 0.3702 |
| black alder | 1896818.20 | 181916.74 | 94.20 | 11.48 | 0.3406 |
| domestic nut | 1640122.46 | 103571.95 | 33.92 | 3.28 | 0.2945 |
| black poplar | 1505030.98 | 243275.93 | 117.13 | 22.77 | 0.2702 |
| small-leaf lime | 1324513.87 | 268630.92 | 88.87 | 21.34 | 0.2378 |
| norway maple | 1115492.66 | 139477.36 | 42.89 | 7.36 | 0.2003 |
| american ash | 840649.75 | 150512.03 | 64.26 | 10.61 | 0.1509 |
| chequer tree | 769120.58 | 43906.98 | 15.22 | 1.22 | 0.1381 |
| ssp\_NA | 756893.58 | 57191.48 | 4.28 | 0.55 | 0.1359 |
| Douglas fir | 743105.01 | 237381.43 | 421.20 | 180.73 | 0.1334 |
| turkish hazel | 703231.00 | 82565.41 | 43.10 | 6.41 | 0.1263 |
| boxelder | 621421.67 | 65382.07 | 31.95 | 4.02 | 0.1116 |
| European white elm | 609323.77 | 99950.02 | 22.71 | 5.71 | 0.1094 |
| eastern white pine | 537748.26 | 180170.10 | 309.54 | 124.81 | 0.0965 |
| mountain elm | 450176.06 | 55386.65 | 29.12 | 5.21 | 0.0808 |
| black walnut | 421828.32 | 198728.38 | 137.20 | 51.48 | 0.0757 |
| white alder | 373600.45 | 94667.71 | 61.90 | 22.26 | 0.0671 |
| European Nettle Tree | 289689.44 | 64759.96 | 36.95 | 8.06 | 0.0520 |
| larch | 265250.62 | 97911.97 | 263.61 | 177.49 | 0.0476 |
| tree of heaven | 154940.68 | 34283.58 | 27.40 | 8.58 | 0.0278 |
| grey willow | 101677.77 | 32624.95 | 48.94 | 15.68 | 0.0183 |
| brittle willow | 76840.38 | 25791.96 | 41.85 | 17.85 | 0.0138 |
| mountain maple | 67280.70 | 24637.04 | 47.24 | 27.98 | 0.0121 |
| rowan | 63346.28 | 12659.92 | 13.21 | 2.95 | 0.0114 |
| honey locust | 63078.92 | 18088.60 | 32.42 | 13.43 | 0.0113 |
| Chinese scholar tree | 62050.76 | 35854.09 | 89.06 | 57.40 | 0.0111 |
| chestnut | 35215.49 | 16472.59 | 44.32 | 17.77 | 0.0063 |
| Siberian elm | 35098.52 | 7564.42 | 10.42 | 2.51 | 0.0063 |
| field maple | 28138.64 | 16114.33 | 0.11 | 0.11 | 0.0051 |
| grey poplar | 2794.37 | 1634.09 | Inf | NA | 0.0005 |
| oriental plane | 755.38 | 441.64 | 3.18 | 2.38 | 0.0001 |
| VOLUME INCREMENT | | | | | |
|  | m3 | SE\_m3 | m3/ha | SE\_m3/ha | % |
| beech | 4144312.92 | 102419.07 | 6.45 | 0.17 | 28.9215 |
| Turkey oak | 1512714.06 | 35146.82 | 2.40 | 0.07 | 10.5566 |
| black locust | 963820.71 | 32568.85 | 2.91 | 0.12 | 6.7261 |
| hornbeam | 950635.31 | 26206.10 | 2.22 | 0.09 | 6.6341 |
| spruce | 770734.76 | 55735.42 | 7.38 | 0.53 | 5.3787 |
| sessile oak | 711141.20 | 21537.93 | 1.90 | 0.07 | 4.9628 |
| black pine | 605635.70 | 35111.99 | 4.73 | 0.31 | 4.2265 |
| Hungarian oak | 544455.42 | 19649.36 | 1.86 | 0.08 | 3.7995 |
| flowering ash | 420677.26 | 13594.23 | 1.35 | 0.06 | 2.9357 |
| EA poplar | 409786.39 | 47103.70 | 13.59 | 1.44 | 2.8597 |
| oriental hornbeam | 327019.91 | 15411.29 | 2.81 | 0.19 | 2.2821 |
| other broadleaf (OB) | 221328.55 | 8397.39 | 0.95 | 0.06 | 1.5446 |
| fir | 216239.27 | 24096.28 | 5.38 | 0.70 | 1.5090 |
| Scots pine | 214060.64 | 19677.40 | 3.13 | 0.36 | 1.4938 |
| european aspen | 209204.72 | 13272.52 | 2.45 | 0.21 | 1.4600 |
| narrow-leaf ash | 206153.05 | 16991.14 | 3.72 | 0.35 | 1.4387 |
| cherry | 180537.77 | 6490.23 | 0.88 | 0.05 | 1.2599 |
| silver lime | 173866.65 | 18702.98 | 3.16 | 0.41 | 1.2133 |
| large-leaf lime | 147292.72 | 13969.37 | 2.72 | 0.36 | 1.0279 |
| pedunculate oak | 145282.34 | 16048.81 | 3.77 | 0.41 | 1.0139 |
| white willow | 109388.46 | 12574.56 | 3.73 | 0.57 | 0.7634 |
| field elm | 94813.08 | 5406.44 | 1.00 | 0.07 | 0.6617 |
| silver birch | 87968.99 | 7021.48 | 1.75 | 0.18 | 0.6139 |
| maple | 85134.18 | 7183.24 | 1.27 | 0.15 | 0.5941 |
| pubescent oak | 79729.18 | 7248.10 | 1.32 | 0.15 | 0.5564 |
| ssp | 79589.13 | 4335.07 | 0.73 | 0.06 | 0.5554 |
| European hop hornbeam | 71243.10 | 7260.89 | 2.00 | 0.24 | 0.4972 |
| white poplar | 70504.61 | 9305.20 | 3.90 | 0.63 | 0.4920 |
| black alder | 66896.90 | 7181.99 | 3.33 | 0.50 | 0.4668 |
| domestic nut | 59938.21 | 3870.82 | 1.24 | 0.13 | 0.4183 |
| European ash | 50620.51 | 4491.39 | 1.40 | 0.16 | 0.3533 |
| small-leaf lime | 48935.56 | 10178.67 | 3.29 | 0.80 | 0.3415 |
| ssp\_NA | 36688.40 | 2993.99 | 0.21 | 0.03 | 0.2560 |
| black poplar | 35354.27 | 5779.90 | 2.76 | 0.53 | 0.2467 |
| american ash | 34466.34 | 6312.61 | 2.64 | 0.53 | 0.2405 |
| norway maple | 30752.65 | 4249.96 | 1.18 | 0.22 | 0.2146 |
| chequer tree | 29312.89 | 1862.47 | 0.58 | 0.06 | 0.2046 |
| European white elm | 22410.29 | 2865.19 | 0.84 | 0.16 | 0.1564 |
| Douglas fir | 18285.87 | 5827.21 | 10.38 | 4.43 | 0.1276 |
| boxelder | 18130.97 | 2270.52 | 0.93 | 0.16 | 0.1265 |
| eastern white pine | 17310.41 | 5714.24 | 9.98 | 3.73 | 0.1208 |
| white alder | 16894.62 | 4388.79 | 2.80 | 1.05 | 0.1179 |
| turkish hazel | 14987.69 | 1707.47 | 0.92 | 0.13 | 0.1046 |
| black walnut | 14898.63 | 6302.94 | 4.85 | 1.90 | 0.1040 |
| European Nettle Tree | 13994.03 | 3132.43 | 1.79 | 0.38 | 0.0977 |
| mountain elm | 10999.77 | 1176.19 | 0.71 | 0.11 | 0.0768 |
| larch | 8640.85 | 3664.99 | 8.60 | 6.98 | 0.0603 |
| tree of heaven | 8146.22 | 1893.33 | 1.44 | 0.46 | 0.0568 |
| rowan | 3659.26 | 854.51 | 0.76 | 0.23 | 0.0255 |
| brittle willow | 2852.17 | 931.41 | 1.56 | 0.67 | 0.0199 |
| honey locust | 2491.69 | 757.42 | 1.28 | 0.56 | 0.0174 |
| grey willow | 2306.88 | 742.98 | 1.11 | 0.38 | 0.0161 |
| field maple | 2235.26 | 1294.79 | 0.01 | 0.01 | 0.0156 |
| mountain maple | 1729.33 | 577.41 | 1.22 | 0.63 | 0.0121 |
| Siberian elm | 1449.93 | 317.00 | 0.43 | 0.12 | 0.0101 |
| Chinese scholar tree | 1073.99 | 532.90 | 1.54 | 0.67 | 0.0075 |
| chestnut | 596.61 | 275.50 | 0.75 | 0.30 | 0.0042 |
| grey poplar | 130.45 | 76.39 | Inf | NA | 0.0009 |
| oriental plane | 40.53 | 23.73 | 0.17 | 0.13 | 0.0003 |

# Serbian NFI2 results improvements with two-phase methodology

The Serbian National Forest inventory is a high-quality study that provides updated and detailed information on the forest structure, biodiversity, and surface, among other important characteristics. The study used a novel sampling design (two-phase sampling) that enabled a higher level of detail and accuracy than previous studies. The study also used satellite imagery to classify the land cover types and to sample many geographic points in a short time.

The two-phase sampling approach also allowed the assessment of the statistical variability of the data, considering the different methods applied at different stages of the study. The main advantage of the two-phase sampling approach is the lower cost of implementation and the improve of the accuracy. The study is a valuable contribution to the knowledge and management of the Serbian forests.

In accordance with the current methodological report, several recommendations have been identified for implementation to enhance the quality of information and ensure a comprehensive and replicable data analysis process in subsequent cycles of the national inventory.

Notably, there are instances of missing data (NA) pertaining to post-stratification variables within clusters where field measurements were conducted. Addressing and completing these cases are imperative to enhance the accuracy of future estimations.

In the context of this report, the statistical procedure was formulated after the estimation of key variables related to forest structure, such as wood volume, basal area, tree density, volume increment, biomass, and carbon stocks, at the cluster level. It is advisable, therefore, to conduct a thorough review of the entire data procedure, extending from tree-level data to plot-level data. As an illustrative example, during the analysis of wood volume (m3/ha) for plots, anomalous values were observed, notably exceeding 400 m3/ha in Serbian forests. Such discrepancies may be attributed to typographical errors in the recorded diameter at breast height (DBH) or tree height.

Considering these findings, a meticulous examination of the data collection process and quality and assurance process is needed, ensuring that the transition from individual tree metrics to aggregated plot statistics is error-free. By addressing these concerns, the reliability and precision of subsequent estimations within the national inventory can be significantly enhanced.

A crucial consideration for the upcoming inventory cycle is the attainment of a unique identifier for each sampling point. Presently, numerical identifiers diverge between the initial sampling phase (remote sensing data, grid 1km x 1km) and the subsequent field data phase (forest structure data, grid 4km x 4km). While it is feasible to harmonize both phases of the NFI2, this undertaking involves the merging of distinct variables utilized in identifying sampling points and clusters during each phase. It is strongly recommended to establish unique identifiers that align with those previously employed, ensuring the seamless comparison of information across inventory cycles and the amalgamation of data from each sampling phase.

In relation with to the results of the present report, it is apparent that the total values for the number of trees, volume, volume increment, biomass, and carbon across all post-stratification variables surpass those presented in the NFI2 report. This discrepancy might arise due to the total forest area used in the two different analysis.

Conversely, mean values of the variables and percentages exhibit similarity. The significance of the two-phase statistical method to the NFI2 lies in its contribution to the understanding of statistical variance information. This encompasses standard errors for all analyzed variables, facilitating an exploration of the heterogeneity within forest information. It allows for an in-depth analysis of cases wherein the forest structure demonstrates greater homogeneity and reliability.

# Annexes

1. rmd file with all the procedure to repeat the results using R Studio
2. Excel with complete results for the two-phase methodology

# References

Cochran, W. G. (1977). Sampling techniques. John Wiley & Sons.

Köhl, M., Lister, A., Scott, C. T., Baldauf, T., & Plugge, D. (2011). Implications of sampling design and sample size for national carbon accounting systems. Carbon Balance and Management, 6(1), 1-20.

Ramírez, C., Alberdi, I., Bahamondez, C. & Freitas, J. (2022). National Forest Inventories of Latin America and the Caribbean – Towards the harmonization of forest information. Rome, FAO. <https://doi.org/10.4060/cb7791en>

Saborowski, J., Marx, A., Nagel, J., & Böckmann, T. (2010). Double sampling for stratification in periodic inventories—Infinite population approach. Forest ecology and management, 260(10), 1886-1895.

Tomppo, E., Olsson, H., Ståhl, G., Nilsson, M., Hagner, O., & Katila, M. (2008). Combining national forest inventory field plots and remote sensing data for forest databases. Remote Sensing of Environment, 112(5), 1982-1999.

1. <https://www.fao.org/3/cb0064en/cb0064en.pdf> [↑](#footnote-ref-1)
2. <https://data.worldbank.org/> [↑](#footnote-ref-2)
3. Food and Agriculture Organization of the United Nations. (2023). Contribution of Sustainable Forest Management to Low Emission and Resilient Development. Retrieved from https://www.fao.org/serbia/projects/detail/en/c/1375467/ [↑](#footnote-ref-3)
4. https://openforis.org/tools/collect-earth/ [↑](#footnote-ref-4)
5. Food and Agriculture Organization of the United Nations. (2023). Contribution of Sustainable Forest Management to Low Emission and Resilient Development. Retrieved from https://www.fao.org/serbia/projects/detail/en/c/1375467/ [↑](#footnote-ref-5)
6. Pantic Damjan, Dees Mathias, Borota Dragan. 2020. Methodology of the second national forest inventory of the Republic of Serbia. Food and Agriculture Organization of the UN. Internal report not published. Belgrade, 2020 (Serbian and English version). 185 pp [↑](#footnote-ref-6)
7. FAO 2023. Forest of Serbia: Results of the second National Forest Inventory. Internal report of the project GCP/SRB/002/GEF Contribution of sustainable forest management to a low emission and resilient development in Serbia (FSP). Belgrade, Republic of Serbia. 56 p (English version) [↑](#footnote-ref-7)
8. Hill, A. and Massey, A. (2021). The R package forest inventory: design-based global and small area estimations for multiphase forest inventories. *Journal of Statistical Software*, 97(4), 1-40. doi:10.18637/jss.v097.i04 [↑](#footnote-ref-8)
9. https://openforis.org/tools/collect-earth/ [↑](#footnote-ref-9)
10. Adolf R. 2023. R code fn\_two\_phase\_ratio\_estimator. [↑](#footnote-ref-10)