Korhonen K.T., Räty M., Haakana H., Heikkinen J., Hotanen J.-P., Kuronen M., Pitkänen J. (2024). Forests of Finland 2019–2023 and their development 1921–2023. Silva Fennica vol. 58 no. 5 article id 24045. https://doi.org/10.14214/sf.24045

Supplementary file S1: Details of volume and increment estimation methods

1. Volume and biomass estimation of trees

We estimated the volume and biomass components of trees similarly as in NFI12. Only the main phases are described here, and a more detailed description is in Korhonen et al. (2021, Suppl. file S1).

1.1. Volume for a sample and tally tree

We estimated the volume of a sample and tally tree using the volume models by Laasasenaho (1982) and, for the alder, aspen, larch and small trees, the models published in Tomppo et al. (2011). The independent variables in these models are the breast height diameter (dbh), height (h), and the upper diameter at the height of six meters (d6) for the trees at least 8.1 m in height. Since the height of tally trees and d6 of any trees were not measured, we estimated models that predict these variables.

For the models of d6 in NFI12 (Korhonen et al. 2021, Suppl. file S1), we used the sample tree data from NFI11 (Korhonen et al. 2017)) and the same models were employed also in this inventory. The height model (Myllymäki 2016, model 18) was fitted in a data set of five most recent years yearly after the field measurements. The linear mixed height model has random factors of clusters and stands for the constant and for the diameter parameters.

1.2. Estimation of volumes by timber assortments for a sample and tally tree

For the sample trees we estimated the stem volumes by the timber assortment classes (saw log, pulp wood and waste wood) by bucking the trunks in such a way that the value of the trunk was maximized (Korhonen 1994, Tomppo et al 2011). If a sample tree contains saw log or other than tree top waste wood parts, the locations of these are assessed in the field. The final bucking is made programmatically, and the taper curve models (Laasasenaho 1982) are used in that.

For the tally trees, we first predicted the proportions of timber assortment classes by tree species groups using smoothing models estimated with the loess function of R (R Core Team 2021). The sample tree data of five most recent years was used in this. Further, we estimated the final proportions by the k-nearest neighbour (knn) method. The independent variables in the knn search were the sample plot coordinates, dbh, h, tree species group and the predicted proportions of saw log and waste wood volumes. We used the same knn search for predicting tree age at the breast height and lower limit of the crown as well for the use in biomass models.

1.3. Estimation of biomass by tree components

We estimated the biomass of the following components for each tally and sample tree: stem, needles, living and dead branches, stumps, and roots larger than one cm in diameter. The possible set of independent variables for different models included tree species, diameter and either measured or predicted tree height, age at breast height and crown height. We used the wood density models of Repola et al. (2007) to predict the stem biomass. For the other biomass components, we used models of Repola (2009) for conifers and models of Repola (2009) for deciduous trees.

2. Increment estimation

The **increment of drain**, i.e. trees that were harvested or died naturally between NFI12 and NFI13, was estimated based on tree-level models, which predict the ratio of the annual increment of the tree and its basal area using NFI12 tree- and stand-level variables as predictors (for details, see Korhonen et al., 2021, Suppl. file S1). The model parameters were estimated from paired sample tree data from NFI9-NFI10, NFI10-NFI11, NFI11-NFI12, and NFI12-NFI13. The average difference in the growth of drain and the growth of survivor trees was accounted for using correction factors based on predicted and measured increments of harvested and dead trees that were alive at the time of the two previous measurements. For trees that were harvested or died between NFI12 and NFI13, increment between NFI11 and NFI12 was used, and so on. To obtain the total increment of drain between NFI12 and NFI13 measurements, the model-predicted annual increments of trees that were harvested or died naturally during that period were finally multiplied by the number of growing seasons between the NFI12 measurement and the time of removal or death as estimated in the NFI13 field measurement.

NFI13 measurements of trees in re-measured plots included the assessment of whether the height of the tree was less than 1.3 m at the time of NFI12, i.e., whether the tree contributes to the **ingrowth**. The increment percentage of those trees was estimated using the increment cores of the sample trees measured on the temporary plots. Also the increments of trees growing on re-measured stands, for which **NFI12 measurements were not available** (due to land-use change or unfound plot center), were estimated based on models fitted to increment measurements from temporary plots. The models included land use change class as a predictor.

References

Korhonen KT (1994) Calculation system for large scale forest inventory. Metsäntutkimuslaitoksen tiedonantoja 505. The Finnish Forest Research Institute, Research Papers 505. ISSN 0358-4283. 36 p.

Korhonen KT, Ahola A, Heikkinen J, Henttonen H, Hotanen J-P, Ihalainen A, Melin M, Pitkänen J, Räty M, Sirviö M, Strandström M (2021) Forests of Finland 2014–2018 and their development 1921–2018. Silva Fennica, 55, 10662. https://doi.org/10.14214/sf.10662.

Korhonen KT, Ihalainen A, Ahola A, Heikkinen J, Henttonen HM, Hotanen J-P, Nevalainen S, Pitkänen J, Strandström M, Viiri H (2017) Suomen metsät 2009–2013 ja niiden kehitys 1921–2013. [Forests of Finland 2008–2013 and their development in 1921–2013]. Luonnonvara- ja biotalouden tutkimus 59/2017. http://urn.fi/URN:ISBN:978-952-326-467-0.

Laasasenaho J (1982) Taper curve and volume functions for pine, spruce and birch. Comm Inst For Fenn. 74 p. URN: ISBN:951-40-0589-9

Myllymäki M (2016) On generalization of sample tree characteristics in the Finnish National Forest Inventory. Natural Resources Institute Finland. Helsinki. 29 p.

R Core Team (2021) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Repola J (2008) Biomass equations for birch in Finland. Silva Fenn 42(4): 605–624. DOI: https://doi.org/10.14214/sf.236

Repola J (2009) Biomass equations for Scots pine and Norway spruce in Finland. Silva Fenn 43(4): 625–647. URN: http://urn.fi/URN:NBN:fi-fe2016101225066.

Repola J, Ojansuu R, Kukkola M (2007) Biomass functions for Scots pine, Norway spruce and birch in Finland. Metlan työraportteja, Working Papers of the Finnish Forest Research Institute 53: 28 p. ISBN 978-951-40-2046-9 (PDF).

Tomppo E, Heikkinen J, Henttonen HM, Ihalainen A, Katila M, Mäkelä H, Tuomainen T., Vainikainen N (2011) Designing and Conducting a Forest Inventory – case: 9th National Forest Inventory of Finland. Managing Forest Ecosystems 22. Springer, 305 s. ISBN 978-94-007-1651-3. DOI: 10.1007/978-94-007-1652-0.