

Chapter 11

Estonia

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11.1 Introduction

11.1.1 Descriptive Statistics

The Republic of Estonia is located in northern Europe on the eastern coast of the Baltic Sea. The total area of Estonia is 45,339 km², with a north-south distance of 240 km and an east-west distance of 360 km. According to the National Forest Inventory (NFI) of 2012, Estonia has 2,2 million ha of forest land which represents approximately half of the country's area (Raudsaar et al. 2014). According to the Forest Act, the definition of forest includes all forest land listed in the land register and any land of at least 0.1 ha with woody plants with a height of at least 1.3 m and a crown cover of at least 30% grow (RT I 2006).

Based on the geographical division of plants, Estonia primarily belongs to the northern area of the nemoral-coniferous or mixed forest belt of the temperate zone of the northern hemisphere. The main tree species is Scots pine which represents 34% of the forest area and 30% of growing stock with a mean volume per ha of 229 m³. The second most important tree species is birch (Silver and Downy) which covers 31% of the forest area and represents 23% of the growing stock. The third most important species is Norway spruce, having a share of 16% of the forest area and 23% of the growing stock. Other species are aspen and alder (Grey and Black) (Raudsaar et al. 2014). Most Estonian forests are mixed forests, only 16% of stands are pure and even-aged (Adermann 2012).

In 1958, the total forest area in Estonia was 1.42 million ha, the total growing stock was 131.18 million m³ and the average growing stock was 103 m³ per ha.

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From 1958 until 2010, the total forest area increased by 55% to 2.2 million ha, the total growing stock increased by 249% to 458.49 million m³, and the average growing stock increased by 113% to 219 m³ per ha (Raudsaar et al. 2014).

11.1.2 Forest Inventory History

In Estonia, two types of national forest inventories are conducted: (1) Standwise Forest Inventory (SFI), and (2) sample plot-based National Forest Inventory (NFI). The NFI started in 1999, whereas the SFI is almost 100 years old. The SFI is carried out by licensed forest inventory companies, whereas the NFI is carried out by the Estonian Environment Agency, which is a state agency administered by the Ministry of the Environment.

In Estonia, forest management requires forest inventory data for every stand, and the data must have been gathered within the last 10 years. Forest inventory is a licensed job in Estonia; thus, only companies that have a forest inventory license can undertake it. At the moment, 14 organizations are licensed, including the Estonian University of Life Sciences and the State Forest Management Centre. The SFI is carried out according to the *Forest Inventory Instruction (FII)* (RTL 2009), which was enacted on the basis of the Forest Act (RT I 2006). The instructions include definitions, methods and mathematical models to assess stand characteristics.

SFI data must be entered into the Forest Register (FR) database which is managed by the Estonian Environment Agency. The data in the FR are partially available for public use in a web-based information system (<http://register.metsad.ee/avalik/>). About 80% of Estonian forests are inventoried by SFI and are represented with data in the FR.

Criteria and instructions for management planning are fixed by law and described in the *Instruction for Forest Management (IFM)* (RTL 2006). This document defines the minimum density before and after thinning, the minimum clear-felling age by species, the minimum number of seedlings for planting, etc. The document was compiled by a working group that consisted of representatives from forest inventory companies, the Private Forest Centre, governmental organizations, and the Estonian University of Life Sciences.

11.2 Forest Inventory Data

11.2.1 Standwise Forest Inventory

SFI data are collected for forest management and are usually re-acquired every 10 years, because forest owners cannot carry out forest management with older data. Traditionally, forest inventories were carried out every 10 years, but nowadays

active forest managers are more interested in updated forest inventory data; thus, their forest inventories are conducted more frequently.

SFI data include two levels of information: stand and stand-element level data which represents a group of trees of the same species in the same storey. At stand level, characteristics such as site type, site index, stand area and volume increment are collected, whereas at stand-element level, tree species are identified and mean height, mean diameter, basal area or number of trees, growing volume, damage characteristics at tree level and age are collected.

According to the FR, in 2013 there were 1.52 million forest stands with a total area of 1.90 million ha and a stand average area of 1.25 ha (Raudsaar et al. 2014).

11.2.2 National Forest Inventory

The first NFI was initiated in 1999 and has been carried out in 5-year cycles (Adermann 2012). The NFI sampling intensity is one sample plot per 1000 ha. The NFI sample plot network includes more than 4600 permanent plots which are measured every five years with one-fifth of the plots re-measured each year. The network contains two types of sample plots: (1) permanent plots measured for growing and standing stock estimation, and (2) temporary plots monitored for regeneration and thinning. Plots have a radius of 7 m (temporary) or 10 m (permanent).

11.3 Data and Methods for Projecting Woody Biomass

The methodology for growth projections, forest management and the models for stand simulation are published in the law (VVM 2008) as well as several algorithms for software development. There is no forest simulator available for public use, although private companies have constructed their own software based on the algorithms in the law.

Species-specific difference equations are used to project the growth in diameter and height and the evolution of the number of trees (Kiviste 1997). Timber assortments are calculated for all tree species based on Ozolin (2002) taper curve models.

11.3.1 Input Data

SFI data are used for growth simulation. The stand-element level input variables are tree species, age, mean diameter, mean height, number of trees. The IFM provides additional information on management thresholds such as the maximum stand density, the minimum density after thinning, the felling age.

11.3.2 Simulation Software

Stand growth is projected in 1-year time-steps using the difference equations until stand cutting age is achieved. Projections of height, diameter and number of trees allow other variables such as volume, basal area and stand sparsity (average distance between trees in meters) to be predicted. Stand growth is projected until stand age equals the final felling age. For each simulation year, stand density is compared with the maximum stand density and if the stand is denser than 95% of the maximum density, thinning is applied. Thinning intensity is based on the minimum density after thinning as specified in the forest management rules. Only intermediate thinning is considered and is implemented by decreasing the number of trees. Thinned volume is calculated by multiplying the volume of the average tree by the number of trees removed. For most tools developed by the companies, when the final felling age is reached, the stand is harvested and stops being projected. However some companies have implemented a stand initialization module based on the previous stand characteristics.

For every thinning and final felling timber assortments are calculated. The costs of silvicultural operations and the current year assortment prices are used to calculate the net present value for each stand.

11.3.3 Outputs

The outputs vary from one tool to another because each company has its own software, and there is no standard output.

11.4 Discussion and Conclusions

Estonia has almost 100 years of history in forest inventory and, therefore, the directive for unifying data collected by companies is well-documented. Inventory and stand variable calculations are carried out according to the FII, and management operations are selected if needed according to the IFM.

For long-term projections of available forest resources using the traditional management regime, a development manual is available for constructing a stand level growth simulator based on SFI data. The advantage of using SFI data is that 80% of Estonian forests are covered by this inventory system; however, the disadvantage is that these data can be outdated because forest management has as long as 10 years to re-acquire data and because data are not rapidly updated after cutting. On the other hand, the advantage of the NFI data is that the sample plots that are measured in the same year form a systematic sample of the entire country and, therefore, are more reliable for country level statistics of forest resources. Nevertheless, only one

sample plot per 1000 ha is measured which makes these data unsuitable for small, single-owner, parcel-level simulations.

No long-term forest resources projection has been made for the whole of Estonia, primarily because the total growing stock has increased by 249% over the last 50 years due to forest area increase and average growing volume per ha increase. Therefore, any projections based on today's data could give results that are in error by more than 100%.

The simulation is used mainly for long-term cash flow prediction for private forest owners about their forest land. In forest science, the simulations are also used in different analyses for selecting final felling age, using management rules, etc. The Copernicus Project (European Space Agency) increases the opportunity to combine remote sensing (radar and multi-spectral imagery) and NFI data for analyses of issues such as land change and forest mosaic which will hopefully result in the development of a new wood availability simulation tool capable of combining NFI and remote sensing data.

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