Chapter 1

INTRODUCTION

Tree growth results from a sequence of physiological processes, consisting of the formation of new cells, cell enlargement, and cell differentiation. Tree physiology deals with the study of these processes and has made a major contribution towards a better understanding of the causal relationship between the production of dry matter and many influential interacting variables. The science of forest growth and yield emphasizes the construction of models describing the relationship between growth parameters and influential predictor variables, and is based on forest botany, ecology, climatology, and soil science. It makes extensive use of forest mensurational techniques and inferential statistics to model tree and forest growth. To a large extent, these studies are of a phenological nature, indispensable to the forest manager in observing and quantifying growth phenomena in relation to time, site, genetic factors, and stand treatment. Forest mensuration provides the methods and tools to conduct such studies. It concentrates primarily on the quantitative assessment of tree and stand characteristics at a given point in time during the life of the tree and stand, and provides the data required for efficient forest management. In line with the North American literature, the authors of this book contend that a discussion of empirical and analytical growth models, because of their technical nature, falls within the discipline of forest mensuration. It is not the purpose of this book to discuss advances in process models. In conclusion, forest mensuration deals with the technical aspects of tree and forest stand measurements, such as:

• Measurement of tree and stand variables, e.g., diameter, height, basal area, bark parameters, and volume of standing and felled trees

• Determination of form and age of trees and forest stands

• Determination of the volume of standing and felled trees

• Measurements of the live crown and quantity of foliage

2 Introductions

• Estimation of biomass and biomass components of individual trees and

Stands

• Estimation of the total and merchantable stand volume and its size class distribution

• Estimation of the diameter, basal area, height, and volume growth of single trees and forest stands

• Estimation of the damages to and the quality of individual trees and forest stands. In addition, it has to deal with the development of models for the construction of tree volume, taper and biomass functions, the construction of stand tables, as well as the development of growth and yield models. Traditionally, terrestrial methods have been used to measure tree and stand variables. More recently, large-scale aerial photography has been applied successfully to replace some of the methods used in conventional ground surveys and it is for this reason that remote sensing methods have been incorporated in this book. In a broader sense, forest mensuration also deals with the estimation of volume and growth of large forest tracts, for example, in regional and national forest inventories, which are needed as a basis for forest policy decisions. This implies the application of modern sampling concepts and sampling methods, which make it possible to draw inferences about the relevant populations. Since so many excellent text books about forest inventory are available already, this book will not deal in detail with the methodology of regional and national forest inventories. A surplus of wood and a limited demand for forest products occurred during the early Middle Ages; therefore, there was no direct need to measure the growing stock at periodic intervals. Towards the end of the Middle Ages, however, the increasing demand for timber necessitated some form of yield regulation. Felling concessions were very much limited to designated areas and replaced single-tree forest exploitation. In Central Europe, the early decades of the 18th century witnessed an increased involvement in a more scientific approach to forest measurements. Attempts were made to classify trees and forests according to their dimensions and their usefulness to the local population, although no exact measurements were carried out. During the first half of the 18th century, foresters made a beginning to improve the customary ocular methods for estimating standing timber. In France Duhamel Du Monceau (1764) initiated dendrometry as an independent scientific discipline and in Germany, Oettelt (1765) issued descriptions for the determination of the volume of felled trees and stacked wood. The last decades of the 18th century and the entire 19th century witnessed a relatively rapid development of forest mensurational methods. Hennert (1791) developed xylometric methods to determine the volume of tree sections by measuring the amount of water displaced by the timber. Hennert also introduced sampling as a device to assess the volume of entire stands. Paulsen (1795) developed the first stem form theory and constructed the first yield tables. Cotta (1804) introduced the caliper and constructed the first volume tables. These early developments paved the way to a scientific basis for forest management and forest yield studies. During the 20th century, there has been an emphasis on the construction and further development of better and more reliable instruments. In recent years, electronic devices for measuring tree dimensions and ring widths have been developed. At the same time, the application of more sophisticated sampling methods made it possible to obtain better and unbiased estimates at lower cost. In 1948, Bitterlich introduced the revolutionaryangle count concept, initially to estimate the basal area per hectare. Some years later, Grosenbaugh (1952, 1958) redefined Bitterlich’s variable radius method as Sampling Proportional to Size.

After early and largely unsuccessful attempts to use medium-scale aerial photographs for forest surveys, Bickford et al. (1963) introduced a twophase sampling procedure, which combined information from a large sample of photo-plots with that obtained from a subsample of plots, which were remeasured with conventional terrestrial methods. During the last decades, largescale color photography was introduced for forest mensurational studies, with emphasis on the measurement of the effect of stresses on needle losses and discoloration. During this period also, satellite images were used for a variety of purposes, but primarily to classify forests according to forest type and to measure or to estimate the areas covered by forest. High resolution satellite imagery, together with digital data processing, opened a new era in forest mensuration on a global scale. The rapid development of electronic data processing and the increasing availability of powerful microcomputers has been of immense importance for mathematical and statistical advances in forest mensuration, particularly because of the inherent possibility of data storage and high-speed processing of quantitative information. Peripheral equipment and computer software to carry out stem analysis was developed and widened the practical usefulness of stem analysis (Johann 1977; Nagel and Athari 1982). In Central Europe, the concept forest mensuration (“Holzmesskunde”) is synonymous with dendrometry and stand measurements. It covers primarily the methods for measuring trees and stands, whereas the concept forest inventory (“Waldinventur”) although being based on dendrometrical methods, deals with estimations and inferences of the volume and growth of larger tracts. Tischendorf’s Lehrbuch der Holzmassenermittlung, Prodan’s classic Holzmesskunde,Akc¸a and Kramer’sWaldmesslehre,Pard´ es’sDendrometrie, and Anuchin’sForest Mensurationwere structured in line with these ideas. In North America, Bruce and Schumacher’s classicForest Mensuration, Spurr’s Forest Inventory, Meyer’s Forest Measurements, Husch, Miller, and Beers’s Forest Mensuration, and Avery and Burkhart’s Forest Measurement combined forest mensuration with inferential statistics, sometimes with modeling, although the emphasis on statistics and modeling varied.