

Contents

1 Introduction	1
1.1 This Book.....	1
1.2 What Measurements are Considered?	2
1.3 Scale of Measurement.....	3
2 Measurements	5
2.1 Measuring Things	5
2.2 Accuracy	5
2.3 Bias	7
2.4 Precision.....	8
2.5 Bias, Precision and the Value of Measurements.....	8
3 Stem Diameter	11
3.1 Basis of Diameter Measurement.....	11
3.2 Stem Cross-Sectional Shape	12
3.3 Measuring Stem Diameter	13
3.4 Tree Irregularities.....	14
3.5 Bark Thickness.....	15
4 Tree Height	17
4.1 Basis of Height Measurement.....	17
4.2 Height by Direct Methods	18
4.3 Height by Trigonometric Methods	18
4.4 Height by Geometric Methods	20
5 Stem Volume	23
5.1 Reasons for Volume Measurement	23
5.2 ‘Exact’ Volume Measurement.....	24
5.3 Volume by Sectional Measurement	25

5.3.1	Sectional Volume Formulae.....	26
5.3.2	Tree Stem Shape	27
5.3.3	Sectional Measurement of Felled Trees	28
5.3.4	Sectional Measurement of Standing Trees	29
5.4	Volume by Importance or Centroid Sampling.....	30
6	Stem Volume and Taper Functions	33
6.1	The Functions.....	33
6.2	Volume Functions	33
6.2.1	Volume from Diameter and Height	34
6.2.2	Volume from Diameter, Height and Taper	36
6.2.3	Merchantable Stem Volume.....	38
6.3	Taper Functions.....	39
6.3.1	Examples of Taper Functions	39
6.3.2	Using Taper Functions.....	41
7	Biomass	47
7.1	Reasons for Biomass Measurement.....	47
7.2	Measuring Biomass.....	47
7.2.1	Branches and Foliage	48
7.2.2	Stems.....	50
7.2.3	Roots	50
7.2.4	Carbon Content of Biomass	52
7.3	Above-Ground Biomass Estimation Functions	52
7.4	Biomass Estimation Functions for Tree Parts	58
7.4.1	Allometric Functions	59
7.4.2	Biomass Expansion Factors.....	60
7.4.3	Leaves	61
7.4.4	Roots	63
8	Stand Measurement	65
8.1	Stands and Why They are Measured	65
8.2	Measurements Taken in Stands	65
8.3	Age	66
8.4	Basal Area	67
8.4.1	Plot Measurement.....	68
8.4.2	Point Sampling	68
8.4.3	Plot Measurement Versus Point Sampling	71
8.4.4	Practicalities of Point Sampling	72
8.5	Stocking Density.....	73
8.6	Quadratic Mean Diameter.....	74
8.7	Dominant Height.....	75

- 8.7.1 Importance of Dominant Height 75
- 8.7.2 Measuring Dominant Height..... 76
- 8.8 Site Productive Capacity..... 77
- 8.9 Volume 80
 - 8.9.1 Plot Measurement..... 80
 - 8.9.2 Point Sampling 81
- 8.10 Biomass..... 82
 - 8.10.1 Root Biomass 82
 - 8.10.2 Fine Root Biomass and Area..... 84
 - 8.10.3 Precision of Biomass Estimates 85
- 8.11 Stand Growth 86
- 9 Measuring Populations..... 91**
 - 9.1 Forest Inventory and Sampling..... 91
 - 9.2 Subjective Versus Objective Sample Selection 92
 - 9.3 Population Statistics..... 93
 - 9.3.1 Measures of Central Tendency 93
 - 9.3.2 Variance and Confidence Limits 93
 - 9.4 Calculating the Population Statistics..... 94
- 10 Sampling Theory..... 99**
 - 10.1 Sampling Techniques and Their Efficiency 99
 - 10.2 Sampling with Varying Probability of Selection 99
 - 10.2.1 The Population Mean and Its Variance 100
 - 10.2.2 Probability Proportional to Size 101
 - 10.2.3 Probability Proportional to Prediction..... 103
 - 10.3 Stratified Random Sampling 106
 - 10.4 Model-based Sampling..... 108
 - 10.4.1 Applying Model-Based Sampling 109
 - 10.5 Choosing the Sampling Technique..... 112
- 11 Conducting an Inventory 115**
 - 11.1 Objectives 115
 - 11.2 Approach and Methods..... 116
 - 11.3 Forest Area 117
 - 11.4 Sampling Units and Calculation of Results 118
 - 11.5 Systematic Sampling 120
 - 11.6 Stand Measurement 121
 - 11.6.1 Shape..... 121
 - 11.6.2 Positioning 121
 - 11.6.3 Size 122
 - 11.6.4 Edge Plots..... 123
 - 11.7 Measurement Errors 123
 - 11.8 More Advanced Inventory..... 124

- 12 The Plane Survey** 125
 - 12.1 Mapping 125
 - 12.2 Survey Example 126
 - 12.3 Conducting the Survey 126
 - 12.4 Calculating the Survey Results 129
 - 12.5 Area of a Surveyed Region 131
 - 12.6 Global Positioning System 133

- 13 Remote Sensing** 135
 - 13.1 Ground Measurement 135
 - 13.1.1 Tree Stems and Crowns Using Lasers 136
 - 13.1.2 Leaf Area Index Using Sunlight 139
 - 13.1.3 Roots 141
 - 13.2 Airborne Measurement 143
 - 13.2.1 Aerial Photography 144
 - 13.2.2 Laser Scanning 146
 - 13.2.3 Spectrometry 148
 - 13.3 Satellites 149

- References** 153

- Appendix A** 171

- Appendix B** 179

- Appendix C** 181

- Appendix D** 183

- Index** 185