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Growth Stresses and Strains in Trees

With 115 Figures

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Cover: Transverse section of *Pinus lambertiana* wood. Courtesy of Dr. Carl de Zeeuw, SUNY College of Environmental Science and Forestry, Syracuse, New York

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Preface

Although over 40 years have passed since Jacobs (1945) convincingly established the basic radial pattern of residual growth stress in growing trees, yet this phenomenon is still not widely appreciated in wood science and technology circles. This is in spite of the fact that the presence of these stresses of sizeable magnitudes has long been recognized as a primary cause of shakes and splits in logs as well as the warping of lumber sawn in the green condition.

The presentation of the subject of growth stresses in trees presents some special problems due to the wide range of specialists who potentially might have an interest in the subject. For example, tree physiologists interested in questions such as the relation of mechanical stress to stem taper and the role of reaction wood and gravity forces in determining tree crown form encounter growth stress models. Silviculturists interested in the relation of thinning practices to wood quality find that wood properties are correlated with growth stress levels which are in turn significantly changed by cutting practices. Wood technologists interested in the relation of residual growth stress gradients in green logs to the dimensional quality of sawn and seasoned lumber are forced to take a more quantitative approach to the effect of growth stresses than might have been the case in the past.

In an attempt to accommodate this rather wide range of potential readers, with very different backgrounds in terms of mathematics and wood mechanics, I have placed the more descriptive and less mathematical material in the first three chapters. In these chapters the experimental results are interpreted by means of comparatively simple and hopefully more intuitive models of the mechanical actions and responses involved. In the later chapters the more technically detailed models of growth stress are presented. As is quite obviously the case when modeling such a mechanically complex material as wood, the mathematical and computational aspects of the subject intensify. However, the level of mathematical sophistication needed to read and understand the models presented, in my opinion, are not beyond what is expected of current students in wood science who use textbooks like Bodig and Jayne (1982) in their graduate studies. Also the availability and wide spread use of "finite element packages" in modern wood science research in laboratories and universities around the world means that models such as those presented here are well within the capabilities of such users.

I am grateful to many persons who helped with the publication of this book. The project got underway while I was on sabbatical leave

in France in 1982 at the École Nationale Supérieure d'Électricite et de Méchanique (ENSEM), the École Nationale Supérieure de la Metallurgie et de l'Industrie des Mines (ENSMIM) in Nancy, and the Centre National de Recherches Forestieres (CNRF) in Champenoux. I would like to express a special note of thanks to Directeur C. Bonthoux at ENSEM, Professeur M. Martin at ENSMIM, and Dr. H. Polge at CNRF for their kind assistance which helped to make this visit very worthwhile.

I would also like to acknowledge the support of the National Science Foundation in Washington D.C. for research grants received over the period 1971–1978 which resulted in substantial contributions to the growth stress models presented in this book.

Another very important source of support over the years has been the Centre Technique du Bois in Paris. In particular, Dr. Walter Kauman, Directeur des Etudes et Recherches and his predecessor Dr. Paul Gueneau have been extremely helpful in support of my growth stress research, especially during the summers of 1980–1982.

During a sabbatical leave in 1975 at Monash University in Melbourne, Australia, I was fortunate in having the opportunity to meet on a regular basis with Dr. Jack Boyd at the Forest Products Laboratory, Division of Building Research, CSIRO. These discussions, which centered on tree growth mechanics and related growth stress questions, were of very great value to me and I am extremely grateful to him for sharing his extensive experience in this field with me.

I would like to thank Shanti Archer, Beverly Duncan, Carl Roner, and Karen Tun for help with the drawings, and Tommy Elder for photographs of the figures. Sue Fulton and Carolyn O'Grady did an expert job of typing the manuscript.

I am indebted to the Editor of this Series, Tore Timell, for his encouragement and help during the preparation of this book. Also a special thanks to Charlie Gatchell of the Northeastern Forest Experiment Station USDA, Princeton, WV, who had helpful suggestions upon reading the first three chapters.

Finally, I would like to express a very deep gratitude to Bill Wilson. Our research collaboration in tree growth mechanics goes back nearly 20 years. The clarity of his thinking and writing on the subject of tree growth has been a great stimulus to my research. He read the first three chapters of the book, and his suggestions were extremely helpful.

Leverett, MA, Autumn 1986 ROBERT R. ARCHER

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