

林业文苑

第二辑

精准林业

冯仲科 赵春江 聂玉藻 余新晓 等著

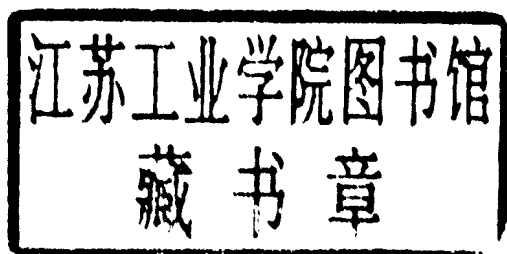
中国林业出版社

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序 一

一个学科成熟的重要标志在于是否更多地采用了定量表达，如果是定性为主或简单的定量描述，这说明这个学科尚在年轻和初始阶段。林学学科数年来诸多模型和现代生物技术、现代空间技术、现代信息技术的引入，有力地促进这个经典学科向高科技武装的、定量表达的现代林业发展。

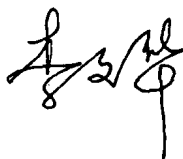
多年来，我国林业管理处于计划经济和粗放经营水平上，经济体制、经营水平、科学技术与我国林业现代化发展不相适应。因此实现两个转变，促进林业发展，改善生态环境，是我国之急务。

冯仲科教授是一位年轻有为的学者，我一向支持他们这批奋发向上、深入实际、富于创新的同志们。他与多位学者合著了世界上第一部《精准林业》，做为他们近年来研究林业模型、空间技术、信息技术应用的结晶。研究中许多构思很有新意，如非线性稳健估计理论、地学统计学理论，广义 3S 对地观测、管理、分析技术体系，森林专家系统与决策分析系统、造林规划设计；精准监测、精准作业、精准喷药、施肥、灭火、管理；电子角规理论与技术、视频超站仪代替森林二类调查和实现单本精准监测、森林保健和森林安全中精准林业技术的广泛应用等。从基础研究、基础技术研究到应用推广，还有精准林业示范基地的建立，这些研究都是有重要学术意义和重大应用价值的。

冯仲科同志 20 余年从事“三下”（林冠下、水体下、地下）

“一上”（特殊构筑物上，如炼钢炉上）精准量测工作，有丰富的实践经验和很好的理论基础。近年来，他结合个人在北京林业大学的教学和科研，围绕他主持的 863、国家自然科学基金、国际合作项目、北京市自然科学基金、北京市农业科技项目和精准林业专题，建立了介于三维工业测量（3D-ISS）、精准农业、林业之间的一门边缘学问——精准林业，从而写出这本值得一读、值得推荐的著作，我向林业、水土保持、资源环境、测绘等方面的学者们、研究生推荐这本著作，旨在推动我国精准林业的发展。

中国工程院院士



2002 年 6 月

Foreword I

An important symbol for the emergence of a discipline lies in the fact that it adopts quantitative methods widely in its research for, generally, if a description makes use of only qualitative methods or simple quantitative methods, the discipline is still in its beginning or immature stage. In the past years, the introduction of various models, modern biotechnology, space technology and information technology into forest studies has effectively modernized the development of the discipline, armed with high technology and quantitative expressions.

For many years, China's forestry management has been affected by the country's planned economy and implemented at the level of extensive administration. The economic system, management and technology cannot meet the requirement of the modernization of forestry. Consequently, it is an urgent task to enhance the development of forestry and improve the ecological conditions.

Professor Feng Zhongke is a young and promising scholar, and I have full support for this enthusiastic, realistic and creative generation of young scholars. In collaboration with several others, Professor Feng has accomplished the task of writing this volume of Precision Forestry, the first of its kind internationally, as a result of many years of research and investigation into the models of forestry and the application of space and information technologies. Much of their research is new, including (1) the theories of non-linear conservative estimation and geonomic statistics, (2) generalized 3S

direct-to-ground observation, management and analytic technology, (3) forest expert system, decision analytic system and silvicultural planning design, (4) precision monitoring, precision operation, and precision spraying, fertilization, fire extinction and management, (5) electronic clinograph theory and technology, (6) the use of video super total station to replace secondary forest surveys and the realization of monometallic precision monitoring, and (7) the extensive application of precision forestry technology in forest health protection and forest security. From basic science, basic technology research to practical applications, including the establishment of the demonstration base for precision forestry, the studies in this volume has important academic significance and major application values.

Through over twenty years of precision surveying under the forest cover, water level and the ground and above special constructions (e. g. the steel-making furnace), Professor Feng Zhongke has accumulated rich practical experience and solid theoretical foundations. In the recent years, he has held many major research projects in precision forestry for the National Science Foundation and Beijing Science Foundation. On the basis of his studies, he has established Precision Forestry as a marginal discipline between Three-dimensional Industrial Surveying, Precision Agriculture, and Forest Science. I recommend this book highly to students and researchers of forestry, soil and water conservancy, resources and environment, and surveying. It is necessary for Precision Forestry to be developed, as indeed this book must be studied and recommended.

Li Wenhua

Academician, Chinese Academy of Engineering

June 2002

序 二

改革开放以来,我国测绘事业出现欣欣向荣的大好局面,特别是空间科技、信息科技、电子科技等现代高新科学技术与测绘学科交叉渗透,使古老的测绘学科内涵不断丰富,外延不断扩展,为我国现代化建设做出了多方面的贡献。精准林业正是现代高新测绘科学技术与林学之间的有机融合,从而促使森林经营管理走向高科技武装的新时代。

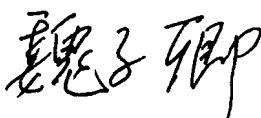
森林是陆地上最大的生态系统,是生态环境建设的重要组成部分。只有通过实施社会经济和资源环境可持续发展战略及科教兴国战略,才能从整体上推进我国现代化进程。我们希望测绘科学技术更好地、深层次地为林业服务,也希望林业工作者为测绘学者提出新的研究课题。

科技事业需要创新。林业界的学者们多年来十分注重将测绘科技与林业生产需要结合起来,遥感用于监测森林动态,近景摄影测量全站仪用于精准测树, GPS 用于森林调查, GIS 用于森林资源与生态环境管理等,这些都是很好的应用创新。我们希望测绘科学与林学科学有机结合,促进边缘学科的发展,推进测绘与林业科技进步。

冯仲科教授是我熟悉的一位测绘与林业学者,他的创新精神、踏实勤奋的态度、社会活动能力都给我以很深印象。近年来,他结合林业对 3S 技术的需求展开了系统的研究,通过他多渠道争取的课题,与十几位合作者辛勤劳动,写出了这本系统

反映精准林业理论、技术与实践的著作，我表示十分赞赏。

我向同志们推荐《精准林业》，希望通过交流和沟通，促进我国精准林业事业的发展。

中国工程院院士 

2002年6月

Foreword II

Since the reform and opening up in 1978, there has been a prospering age of the surveying enterprise in this country, especially in its cross-disciplinary studies with space, information and electronic technologies. Consequently, the traditional surveying has been enhanced and enriched, thus making new contributions to China's modernization drive. Precision Forestry has emerged as a combination of the contemporary high and new surveying technology with the study of forestry. It means that the management of forests has entered a new age armed with high-technology.

As the largest terrestrial ecosystem, the forest is an important component of the development of the ecological environment. The sustainable development of social economy and environmental resources and prospering China with science and education are two major strategies in propelling the drive of China's modernization. We hope that the surveying technology can better serve forestry at a deeper level, and our surveying workers can find new projects to work on from the forest workers.

The scientific enterprise requires creative minds. For a long time, the forest scholars have tried to combine surveying technology with the needs of forest production. They have been creative in applying remote sensing to forest monitoring, close-range photogrammetry total station to precise tree measuring, GPS to forest surveying, and GIS to the management of forest resources and ecological environment. We hope that the surveying science and the

forest science can work together to promote the development of cross-disciplinary studies so that the technology of surveying and forestry can both be enhanced.

Professor Feng Zhongke is known to me as an accomplished scholar in the application of surveying technology to forest studies. His originality, diligence and abilities have left me a deep impression. In recent years, he has carried out a series of studies in the needs of 3S technology in forestry, while this book is the result of his many projects and collaboration with others. I appreciate this work for its systematic reflection of the theory, technology and practice of precision forestry.

I therefore recommend this book to all my colleagues, and hope that it will promote the development of precision forestry in China.

Wei Ziqing

Academician, Chinese Academy of Engineering

June 2002

前 言

精准林业是应用三维工业测量（3D-ISS）的技术、精准农业的思想去建立现代林业技术体系。概而言之，所谓精准林业，就是进行精准的森林时空观测，建立精准的森林时空模型，实现精准的森林时空分析，规划精准的森林时空调整，实施精准的森林时空作业，达到理想森林时空目标，从而使森林最大限度地发挥生态效益、社会效益和经济效益。

我从事测绘科学技术的学习、教学、科研已多年，出于工作单位的缘故，所从事的测绘科研、教学、实际工作可归纳为“三下”（林冠下、水体下、地下）“一上”（特殊构筑物上，如炼钢炉上等），前后承担的相关大小项目不计其数，精度要求也很高，八宝山林冠下测地形通视的尴尬，南屯煤矿移动盆地水下测地形的危险和艰难，京西小煤矿打贯通时的提心吊胆，首钢高炉改造时测绘的恶劣环境，这些都造就了我从事复杂环境精准测绘的经验，更激发了实现“三上一下”环境自动精准测绘的热情和信心。十年前，我开始指导研究生从事三维工业测量课题研究，七八年前，我又对精准农业产生了浓厚的研究热情和兴趣。五年前，我调入北京林业大学从事测绘与林业 3S 技术与教学工作，北京十三陵林场二类调查和西北林业考察之行对我感触很大，林业要现代化，必须首先实现森林资源调查和管理的现代化和精准化，于是，我就着手研建具有我国特色的精准林业体系。1998 年初，我提出并定义精准林业概念，此后几年，我主持国家自然科学基金中国西部环境和生态科学重大研究计划“森林生物量定位精准监测模型与技术基础研究”（90302014）、国家 863 计划“森林精准监测与重大病虫害遥感监测

及预警系统研究”(2003AA245030)(滚动支持)、北京市自然科学基金重点项目“北京市森林植被景观信息四维表达应用基础研究”(04D130)等分别从基础、技术、高技术、应用、示范基地建设等方面支持我们这项研究,显然,没有项目的支持,这项研究工程不会有如此迅速的进展,第一本专著也会无力出版。

全书共计六章,张晓丽著第二章第五节,第三章第一节、第七节,第五章第一节;孟宪宇著第四章第五节、第五章第三节(部分);吴保国著第三章第六节;胡涌著第五章第二节;郝建华著第三章第八节;李国光著第三章第三节;王海龙著第一章第一、二节。岳金柱著第五章第三节及第六章第一节。其余由冯仲科、赵春江、聂玉藻、余新晓合著。整个著写过程中,我们的博士和硕士研究生官凤英、景海涛、谭伟、付晓、周科亮、田昕、杨永恬等做了大量相关文字、图表、实验和研究工作。北京林业大学外语学院院长史宝辉教授翻译序、前言及目录。全书由冯仲科总体策划,冯仲科、张晓丽整体统稿。

本书初稿曾在北京林业大学研究生课程及国内许多单位多次讲授,根据反映调整了许多内容,中国工程院院士、著名的林学家、生态学家李文华教授,中国工程院院士、著名测绘专家魏子卿研究员百忙之中欣然为本书作序,韩熙春教授审阅全书,诸多的单位和朋友们关注此书出版,在此一并表示感谢。限于个人水平和学科的年轻,书中缺点错误,敬希指正。

冯仲科

2002年6月

Preface

Precision forestry aims to establish a modern forest technological system by applying the technology of 3D-ISS and the ideology of precision agriculture. In a nutshell, precision forestry means to obtain maximal ecological, social and economic benefits from the forest by applying precision temporal and spatial observation of the forest, establishing precision temporal and spatial models for forests, realizing precision temporal and spatial analysis of the forest, planning precision temporal and spatial readjustment for forests, implementing precision temporal and spatial forest operations, and reaching an ideal temporal and spatial forest objective.

Having studied, taught and researched in surveying technology for many years, I have undertaken projects with three 'unders' and one 'above' (under the forest cover, the water level and the ground, and above special constructions, e. g. above the steel-making furnace). The numerous surveying projects I have been engaged in, including the embarrassing experience of surveying the typographic intervisibility under the forest cover at Babao Mountain, the dangerous work of surveying the underwater typography at Nantun Coal Mine, the risky task of making a cut-through at a minor coal mine in West Beijing, and the atrocious conditions of the surveying assignment when the Capital Steel Works reconstructed its furnaces, have all required high precision. All these experiences have trained my abilities of making precision surveying under complicated conditions, and awakened my enthusiasm and confidence of realizing

automatic precision surveying in the environments of three 'unders' and one 'above'. It was a decade ago that I started supervising graduate students on research in 3D-ISS projects, and two or three years later I began to take an interest in and soon became enthusiastic about precision agriculture. Five years ago I got an appointment at Beijing Forestry University (BFU) to teach and do research in surveying and the application of 3S technology in forestry. The secondary survey of the Ming Tombs Forest Farm in Beijing and the forest investigation trips to Northwest China made me feel that the modernization of forestry lies first and foremost in the modernization and precisionization of the surveying and management of forest resources. Since then I have been undertaking research into the systematic establishment of precision forestry, with Chinese characteristics. At the beginning of 1998, I established and defined the concept of precision forestry. For the years since, I have been holder of numerous projects for the National Foundation of Natural Sciences, the National 863 Plan, and the Beijing Foundation of Natural Sciences. These projects have given us support to do research in the basis, technology, high-technology, application, and the development of demonstration bases for this technology. It is obvious that without their support the study of this technology cannot have progressed so fast, and there has been no possibility for the publication of this book.

Although I prepared the outline and overall plan of the book, it is the effort of many people. Apart from 2.5, 3.1, 3.7, 5.1 (written by Zhang Xiaoli), 4.5, part of 5.3 (by Meng Xianyu), 3.6 (by Wu Baoguo), 5.2 (by Hu Yong), 3.8 (by Hao Jianhua), 3.3 (by Li Guoguang), 1.1, 1.2 (by Wang Hailong), 5.3 and 6.1 (by Yue Jinzhu), all the other parts are written by the authors of this book. We are grateful for our graduate and Ph. D. students, especially Guan Fengying, Jing Haitao, Tan Wei, Fu Xiao, Zhou Keliang,

Tian Xin, and Yang Yongtian, who helped us with typing, graphics, experiments and research. Zhang Xiaoli also helped me in reading through the complete manuscript and making corrections on the drafts that our co-authors have written. Finally, a special thank goes to Professor Shi Baohui, Head of the School of Foreign Languages at BFU, for the English version of the forewords, this preface, and the table of contents in this book.

The manuscript of this book has been used with the graduate students at BFU and in training courses at other places. We are grateful for the comments and feedback our students have given us. We are also grateful to Professor Li Wenhua, Academician of CAE and renowned forest scientist and ecologist, and Professor Wei Ziqing, Academician of CAE and renowned surveying scientist, who have spent the time reading part of the manuscript and written the forewords. Professor Han Xichun read through the complete manuscript. Of course, any errors or mistakes that still exist in the book remain to be the responsibility of the authors and comments from readers and specialists are always welcome.

Feng Zhongke
June 2002