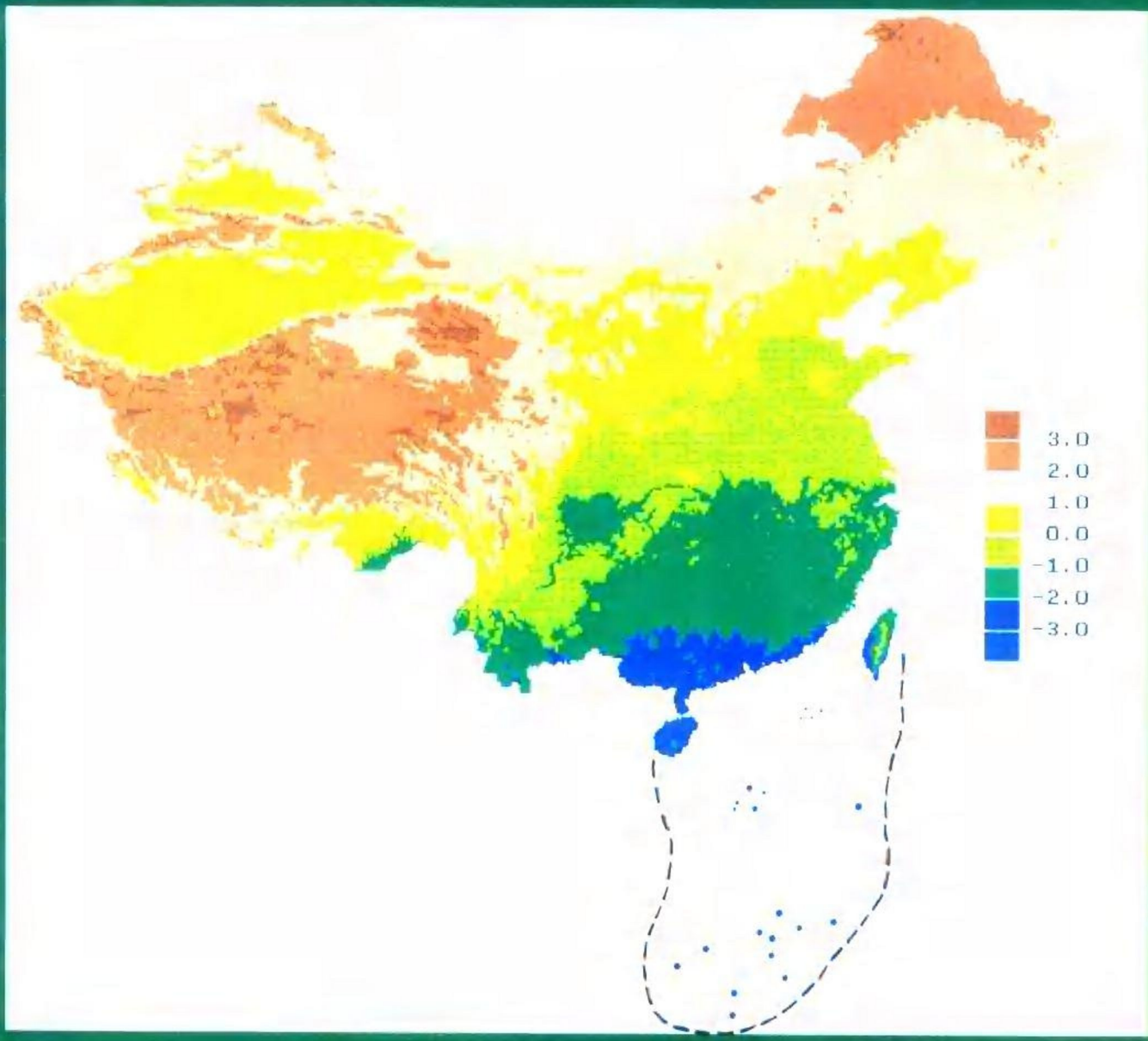
中国林木育种区

顾万春 著　　游应天 校



●中国林业出版社

中国林木育种区

Forest Tree Breeding Regionalization in China

顾万春　著
游应天　校

CFPH
中国林业出版社

本书是“八五”国家科技攻关林木良种选育课题中“林木种质资源保存技术”(85－081－01－16)部分研究内容，是林业部重点课题“中国林木育种区划研究”(90－91－02)的研究成果。值此，谨向国家科委农村科技司、林业部科技司深表感谢和敬意。

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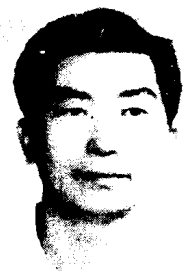

顾万春，男，1941 年 10 月生于江苏省。1965 年毕业于南京林学院（现南京林业大学）林学系本科，同年分配到中国林业科学研究院林业研究所从事研究工作。1970 年 11 月至 1977 年 6 月在河北林学院任教“林木遗传育种学”，1977 年 6 月返中国林业科学研究院林业研究所从研至今。为该院、所林木遗传育种研究室主任，研究员，研究生导师。

从事科研、教学 30 年来，进行了 7 个针阔叶树种约 20 个课题的遗传育种研究，通过鉴定的研究成果 11 项，获林业部科技进步 2 等奖 2 项，3 等奖 2 项，中国科协首届优秀建议一等奖（集体）1 项，中国林学会陈嵘学术奖 1 项。著书 1 部，编著书 3 部，主编、副主编书 2 部，共约 198 万字；发表论文和研究报告 64 篇。在森林生态遗传学、森林统计遗传学、林木育种学等研究领域取得显著成绩，同时，是“我国林业的主要矛盾和对策”、“我国 1 亿亩速生丰产林技术路线和对策”等宏观决策论文的主要执笔人。“八五”国家科技攻关“林木良种选育”（85－018－01）课题技术负责人之一，“林木种质资源保存与利用”（85－018－01－16）专题主持人。获“林业部有特殊贡献的中青年专家”称号。

内容简介

《中国林木育种区》是一部对我国林木育种研究和林木良种事业的总结与应用著作，是一本研究成果专著。研究提出中国林木育种区“3+1”等级和评价标准，将全国划分为10个林木育种大区，97个林木育种区，74个亚区，同时确认31个省、直辖市、自治区为林木育种基本区；绘制出“中国林木育种区区划与生态梯度”图，林木育种区生态因子、生态梯度值、树种区及林木育种策略4套表格。研究综合生态因子采用因相关（CA）跟进主成分分析（PCA）方法，获得1元生态梯度值（EGA）及其定量区划技术具有创新性。全书6章内容，并附有英文前言，各章英文摘要和数十幅图表。后3章介绍了与林木育种区区划关联的应用基础理论和应用技术的衍生问题，具有实用性，是一本颇有新意的好书。

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序

森林是陆地生态系统的主体，是地球上最典型、最多样、最重要的生态系统；是包括木本植物在内的动物、植物、微生物栖息繁衍场所，与人类的生存与繁荣休戚相关。当前，森林资源日益减少，生态环境日趋恶化，已成为全球性热点问题之一。在环境和经济发展大目标下，增加森林资源，提高森林生产力和环境效益，势必成为我国科技发展的重大命题。当今世界林业正处在利用天然林木材过渡到营造人工林，实现森林资源可持续利用发展新阶段，人工林可持续发展的关键技术是林木遗传改良。这就是说，林木遗传改良和保护生物多样性是达到以上目标的重要手段。而林木育种区区划，是林木育种事业、林木遗传多样性保护与评价的技术保障。

林木育种区及其分类系统，是在研究广域生态梯度之后，人为划定的多级地区的基础上，兼顾林木遗传改良和林木良种生产布局的地域单元。它不同于以林业生产布局为重点的林业区划，不同于仅依据单项自然因子(组)的气候区划或土壤区划，不同于具有专项目标的造林区划、森林立地区划、林价区划等专业性很强的区划，也不同于单一树种以种子调拨为主要目的种子区划或种源区划。林木育种区区划是以综合生态因子——生态梯度为定量区划依据，利用森林植物与生态相似论原理，消化吸收林业同类区划的有用信息，采用多图叠合校正技术，并兼顾组织林木育种事业的现行行政区划，最终研制出实用性强的综合性区划，是多学科知识结晶的科研成果。

该书作者以及课题组成员为此付出艰辛努力，所研究的综合生态因子降维，采用因子相关分析(CA)跟进主成分分析(PCA)，获得1元生态梯度值(EGA)进行定量区划，研究的方法论具有创新性。区划结果的育种区分类系统便于全国和地方组织实施，书中提出各育种大区、育种区(亚区)的林木育种策略要点，同时，重点介绍了理解和使用林木育种区划相关应用基础理论和衍生应用技术问题，具有实用性。是一本颇有新意的好书。

林木育种区划研究，是对中国40多年来林木育种科技成果的总结和利用，是两代人为之奋斗的结果，在中国尚属首次。相信，随着林木良种事业及林业事业的发展，林木育种区划将进一步得到检验和提高。

1995年8月

前　言

林木育种，又称林木遗传改良，是研究特定生态环境条件下对森林遗传资源加工利用的科学，是一门筛选（含创造）林木遗传材料与生态环境优化配置的应用学科。近20年来，我国林木育种研究和良种化生产事业，成绩斐然，已成为营林生产中举足轻重的“龙头”技术；但从林木育种在林业发展和环境发展的现实与战略位置上来看，我国林木遗传改良工作缺乏系统性、超前性和实用性，缺少与之匹配的应用理论研究。由于育种策略、目标和技术路线受短期行为制约，育种策略不明确，育种方法论不完善，尤其是对育种材料与生态环境的时空优化效应认识不足，影响了研究效率和林木良种生产。

林木育种区区划是对林木育种工作的总结与应用，在林木育种研究和林木良种事业方面占居重要的位置。我国地域横跨5个气候带，地貌类型多样，树种资源和遗传资源十分丰富，自然条件复杂，现有部分主要造林树种种子区划，无法覆盖全国，缺乏统一的生态和营林指导意义。因此，林木育种区区划研究更显得重要和迫切。林木育种区区划是对历史长河中森林与环境交互作用与进化演替所形成的森林区系及森林生态类组的界定，是现实经济发展中的体现。生态育种的地域区划，是集生物学、生态学、经济学于一体的寻求指导森林遗传多样性与生态系统多样性优化配置的地域划分。她遵循“物竞天择”、“适者生存”、“配置优化”等自然法则与经济原则，客观地人为划分林木育种区分类系统，为林木遗传改良和环境发展服务。我国50年代就有林木育种区区划的动意和设想，1979年全国林木育种规划座谈会（北京）讨论了林木育种区区划和亚区区划的原则意见，由徐纬英和顾万春共同起草了“中国林木育种区划”一文（“研究报告”，1980，第2期）。但由于当时条件所限，工作不够细微深入，没有达到实用程度。1990年2月中国林业科学研究院林业研究所上报课题申请书，同年林业部科技司正式批准该课题，课题名称：中国林木育种区区划研究，编号：90－91－02。1990年10月科技司和课题组签订课题合同，年底制定完成课题实施计划。

1991～1992年课题组完成国内外同类区划资料收集与气象资料收集，确定统计分析技术及建立数据库。已建成的数据库包括：①全国4组气象资料数据库；②17个树种种源及种子区划数据库；③生态梯度轴（EGA）以及趋势面分析和内插函数分析图表数据库；④中国林木育种区分类系统及相应图、表数据库等。1993年，研究确立中国林木育种4级分类系统，撰写研究报告及总报告。

1994年上半年，将研究报告和总报告，包括3套表和11张区划图成套报送林业部科技司领导，并发送高等院校、部分研究部门和重点省、直辖市、自治区林木种苗管理部门，征求修改意见。1994年6月，在安徽省黄山由林业部国营林场和种苗管理总站召开的部分省、直辖市种苗站长会议上，对区划原则、方法和结果进行了讨论。会上在充分肯定区划原则、方法和区划系统的科学性和实用性的同时，对部分省的育种区及亚区区划结果提出了修改意见。

该项研究在系统借鉴、收集、消化国内外同类区划研究成果与信息的基础上，根据国情、林情及自然规律与经济规律，研究提出中国林木育种区区划的4项原则；依据影响林木育种的综合生态因子，包括气象因子、地理因子、树种因子、林木种子区和林木种源区的研究结果，研究确定综合生态因子降维定量区划、插值拟合和多图叠合的区划方法；提出与实施定量区划和定性拟合的4阶段区划程序。

1994年下半年，课题组在征集各方面意见基础上，进一步对区划初稿进行了完善和提高。

1994 年 12 月，由林业部科技司主持鉴定该项成果。鉴定意见是："该项研究立题正确，研究目的明确、收集的资料覆盖面广，数据量大，特别是研究方法先进，定量研究技术和数据、图形处理技术新颖。研究成果系国内首创，达到国际同类研究的先进水平。"本书是"中国林木育种区区划研究"成果专著。

本书主要内容是 4 个研究成果的连锁和组合。①以全国 678 个气象台站为样本，各样点 15 个生态因子，通过因子相关分析(CA)，跟进采用成分分析(PCA)，将每样点 15 个生态因子降维成 1 元，即生态梯度(轴)值(EGA)，勾划出全国生态梯度等值线图，降维精度约为 69%；②运用拉普拉斯样条函数插值法，估算出全国 97000 个网点生态梯度值，打印成彩色生态梯度地图。并运用趋势面分析打印出 EGA 黑白地图；③在生态梯度地图和生态梯度等值线图上，采用大值和小值两重区划，区分出林木育种大区、育种区及亚区；④用 13 个树种种子区划、17 个树种种源区划以及相关林业区划等进行叠合，并用行政区划投合。研究提出中国林木育种区的"3＋1"区划等级和评价标准，共划分出 10 个林木育种大区，97 个林木育种区，74 个亚区，同时确认 31 个省、直辖市、自治区为组织林木育种的基本区。区划结果绘制出"中国林木育种区区划"图，以及相应的育种区地理生态因子、生态梯度值、树种组和林木育种策略 4 套表格。

该项研究成果将对我国林木育种研究和林木良种事业有着积极贡献。成果的实用价值与学术意义在于：

(1)首次建立了中国林木育种区区划的分类、评价系统。

(2)定量区划方法研究中，突破了常规多元排序技术，在国际上首次采用跟进两种多元分析方法降维，将多元生态因子降维成 1 元，即生态梯度轴(EGA)值，生成生态梯度等值线图与生态梯度地图，定量区划，多图叠合检验，具有很高的科学性和适用性。有关技术为国内外首创。

(3)制定出林木育种大区和组织林木育种基本区的树种组、育种策略和育种目标，能较大地提高林木育种研究效率。对于发展我国林木育种研究具有重要战备意义和现实意义。

(4)指导我国林木良种生产布局和决策，提供生态环境分层规范，对林木育种中心和良种繁育中心建设具有现实意义，是新型林木良种事业的重要组成部分。

(5)为我国森林遗传资源保存提供区域生态依据。为林木育种研究中育种材料的地域差试验林、立地差试验林设计和配置提供依据，减少试验损失，提高试验效率。

(6)该项研究成果已被批准同步转化为国家标准。有利于与已制定的同类标准接轨，为同类国家标准与行业标准提供了生态区域依据。

林木育种区区划研究成果是该书的主体内容，但不是全部内容。在本书的后三章增加了"林木育种区及应用理论"，"林木育种区与林木育种试验效率"及"生态梯度与预测生态遗传的研究实例"。这样安排是为增加读者对森林群体、生态遗传和生态环境分层的知识，以提高对林木育种区区划的原则、方法的认识，拓广思路，提高对林木育种区区划结果的应用能力和认识水平。

在中国林木育种区划研究过程中，林业部国营场圃种苗工作总站以及黑龙江、吉林、辽宁、北京、河北、山东、河南、山西、陕西、甘肃、新疆、内蒙古、安徽、浙江、江西、湖北、湖南、四川、贵州、云南、福建、广东、广西、海南等省、直辖市、自治区林业厅林木种苗站主要负责人给予大力支持和真诚协助。在本书编写过程中得到中科院院士、研究员吴中伦先生和林业部副部长、教授刘于鹤先生悉心指导，林业部科技司司长刘效章先生、副司长寇文正先生、林业部国营场圃种苗工作总站站长王棋先生、林业部计划司副司长张佩昌先生、林业部科技司计划处处长杨

梅先生给予热心帮助和指导，在此一并表示深切感谢。值此机会，还要感谢该项成果鉴定委员会的专家们，他们是：主任委员王棋总站长；副主任委员沈熙环教授；委员洪菊生研究员、徐孝庆教授、黄敏仁教授、潘本立研究员、张颂云研究员、施季森教授、周冰总工、杨传平教授、张佩昌副司长等。

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	阎　洪	副　研	中国林业科学研究院林研所

最后，书中错漏和不当之处，恳望读者指正。

顾万春

1995年6月

PREFACE

Forest tree breeding, or genetic improvement of forest trees, is a science that deals with thedevelopment and utilization of forest genetic resources for different environmental conditions, whichis an applied technology for finding out or creating the optimal interaction between forest geneticmaterials and ecological environment. During the latest 20 years, China has achieved significantprogress in research of forest tree breeding and production of improved planting materials, which havebrought about the decisive technical components in silvicultural operation. However, the forest treebreeding work is still not perfect in systematicness, advancement and applicability in China,considering its important strategic position in development and environmental construction. Forexample, the research on related genetic theories was not enough, and the breeding strategy, objectiveand techniques were limited at short—term benefit, and the breeding methodology was not welldeveloped, especially, the optimal spacial and time interaction between breeding material andecological environment were not fully understood, which negatively influenced on the efficiency ofbreeding research and benefit achievement in production of improved planting materials. Forest tree breeding regionalization is one of the most important links in tree breedingresearch and planting material improvement, as it is a summary and application of the achievedbreeding research results. China has a large territory that covers five climatic zones with complexgeomophological varieties, which result in extreme richness of tree species and genetics resources inthe whole country. The existed Seed Regionalization of Main Afforestation Species is not perfect, asit tells only few tree species and ecological regions in the country and couldn't be used as a guidanceto the general forest management and ecological protection of national forest resources. Therefore,the forest tree breeding regionalization is quite necessary and urgent to be studied and worked out.

The forest tree breeding regionalization is to define the forest formations and forest type—groups that were formed depending on the interaction of forest and environment and the forestsuccession and evolution, which is the requirement of the economic development. The regionalizationof ecological breeding zones is an integrated scientific system that combined biology, ecology andeconomics together, which will try to search for the optimal matching of forest genetic diversity andforest ecological diversity. The principles, such as "natural selection", "survival from adaptability"and "optimal matching" etc., will be followed in the regionalization, so that the forest tree breedingregions could be divided according to the natural law. Therefore, the regionalization can well servethe forest genetic improvement and the environmental construction.

The first intention to conduct a tree breeding regionalization initiated in 1950s. The principlesof making a division of tree breeding regions and sub—regions were discussed at the Workshop onNational Forest Tree Breeding Planning held in Beijing in 1979, and a summary report was writtenby Xu Weiying and Gu Wanchun entitled "China Forest Tree Breeding Regionalization". As the workconditions were not available for us to continue the study at that time, the detailed forest tree breedingregionalization was not completed. A formal project proposal entitled "Research on China Forest TreeBreeding Regionalization" was prepared by the Research Institute of Forestry, CAF and affirmed bythe Department of Science and Technology, Ministry of Forestry in February, 1990. Then, the projectcontract was signed between the Research Group and the Department of Science and Technology inOctober, 1990 and the implementation plan of the research project was drawn up by the end 1990.

During 1991 to 1992, the Research Group collected the relevant materials from both domesticand overseas publishes, as well as the nation—ranged climatic data, based on which the statistics wereconducted and several data basis are established. The main data basis are Nation—Ranged Data Baseof Four Climatic Factors, Data Base of Seed or Provenance Regionalization for Seventeen TreeSpecies, Data Base of Diagrams for the Analysis of Ecological Gradients Axis and Data Base of theClassification System of China Forest Breeding Regions (Maps and Tables) etc.. In 1993, the four—class classification system for China forest tree breeding regions was worked out, and many studyreports and the conclusion report were drawn up.

In the first half of 1994, the study report and conclusion report, including 3 sets of tables and11 maps of the regionalization, were presented to the Department of Science and Technology, Ministryof Forestry, and sent to the related forest universities or colleges, institutes and some provincial seedand seedling management stations to solicit their opinions. At the meeting of directors of provincialseed and seedling stations held by the Station of Forest Farm and Nursery, Ministry of Forestry inHuangshan ,Anhui in June, 1994, the draft document of regionalization was discussed. The majorityparts in the document, such as the principles, methods and results of the regionalization, wereconsidered to be scientific and applicable, and some comments were also given for the revision of theregionalization document.

In the second half of 1994, the Research Group revised the first document of regionalizationbased on the collected ideas and comments in order to enable it more perfect. The final achievementof the research project was appraised by a specialist committee organized by the Department ofScience and Technology, Ministry of Forestry in December, 1994. The appraisal words said thataiming at a clear and correct objective, the research

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was implemented by collecting large amount ofreference materials or data that related to the research subject and adopting the advanced studymethods of the combination of quantitative analysis and diagram expression, which has resulted in afirst creation of the national tree breeding regionalization and has reached the advancing level in thesimilar study fields of the world.

This book is the result of the research project on forest tree breeding regionalization. Basedon the careful collection, digestion and absorption of the existed information about the regionalizationstudies in the world, the four main principles were defined for the tree breeding regionalization inChina, according to the national circumstances in natural and economic aspects that related to forestrydevelopment. A new regionalization method of one or two dimensional coordinate by the integratedecological factors that were derived based on the analysis on the climatic, geographical and treespecies factors and the reference of the achievements in seed or provenance regionalization researcheson forest species, which has resulted in a regionalization programs of four stages, with thecombination of the quantitative division and qualitative simulation of value inserting and mapsoverlapping.

The main contents of the book are consisted of four items of research achievement as follows:

a. The factorial correlation analysis (CA) and the principal component analysis (PCA) wereconducted on the 15 ecological factors that were collected from 678 climatic stations distributedthroughout the country, to decrease the 15 dimensions into one dimensional coordinate of ecologicalfactors, i. e. ecological gradient axis (EGA), and the equal value lines were drawn out on the map ofChina according to the EGA values of the 678 climatic stations, with the precision of 69% fordimension decreasing from fifteen to one.

b. The estimation of EGA values was made for the 97,000 grids of whole country by usingthe method of Laplas spline interpolation, and the colorful map with EGA values was printed. Meanwhile, the trend surface analysis was conducted and several maps of EGA were also printed.

c. On the map with EGA values and the map with lines of equal EGA value, the division offorest tree breeding region groups, regions and subregions were made with different levels of EGAvalue.

d. The existed seed regionalization maps for 13 tree species and provenance regionalizationmaps for 17 tree species, as well as other related forestry regionalization maps, were used byoverlapping them on two maps of EGA value in consider of the administrative regions, so that the"3+1" division classification and evaluation criteria were identified for forest tree breedingregionalization in China, with which overall 10 breeding re-

gion groups, 97 breeding regions and 74breeding sub—regions were classified and defined for the whole country, in addition, the administrativebreeding districts were grouped for the 31 provinces, autonomous regions or municipal to conveniencethe application regionalization in the cooperative tree breeding between them. As the result, a map offorest tree breeding regionalization in China and five sets of tables for the related geographical andecological factors, EGA values, tree species or species groups and their breeding strategies in eachbreeding region were also made.

As a summary and application of the research results in tree breeding so — far achieved inChina, the forest tree breeding regionalization shows its the theoretical and applied value as follows.

a. A complete system of classification and evaluation of forest tree breeding regionalizationin China was firstly worked out.

b. The appropriated tree species or species groups, breeding strategies and breeding objectiveswere defined for the breeding region groups and the administrative breeding districts, which will behelpful to the efficiency of tree breeding research and of a great significance to the development ofbreeding research in China.

c. The regionalization is a guidance to the decision making for the distribution and productionof improved planting materials and a reference to the herachical classification of the ecologicalenvironment related to tree breeding, which could be applied in the establishment of tree breedingcenters and multiplication center of improved planting materials. It is also an importance of the newsystem of forest tree breeding.

d. The regionalization could provide the regional ecological basis for the conservation of forestgenetic resources in China, and for the rational design and distribution of the tree breeding trials ondifferent seed sources or site conditions so that the experimental losses could be reduced with theincrease of breeding efficiency.

e. When the quantitative method was studied and applied for regionalization, the multiplevariable analysis was adopted repeatedly to decrease the multiple dimensions into one dimension ofthe multiple ecological factors, i. e. EGA , which was firstly used for the quantitative regionalizationin the world, other than the usual method of multiple variable ordering for regionalization. Furthermore, the map with lines of equal value of EGA and the map of EGA values were created forthe quantitative regionalization, with the simulation and correction of the final regionalization result, which enable the research conclusion more scientific and more applicable.

f. This research achievement has been approved to be transferred into the National Standardof forest tree breeding regionalization, which will supplement to the existed national or special fieldstandards on forest tree improvement in China.

Though the main contents of the book are about the forest tree breeding regionalization, thereare still three chapters, i. e. "Review on theories used in forest tree breeding regionalization", "Foresttree breeding regions and tree breeding trials" and "Case study about the application of ecologicalgradient and breeding materials to ecological adaptability research in both time and spacialdimension". These chapters will help readers to learn the knowledge about how to group the factorsof forest population, ecological genetics and ecological environment at different levels, so that theycan well understand the principles and methods for forest tree breeding regionalization and well applythe regionalization result to their research or production practice.

During the implementation period of the research project of Forest Tree BreedingRegionalization, we have received a lot of assistance and truthful help from many institutions, e. g. ,the General Station of Forest Farm and Nursery, Ministry of Forestry, and the provincial seed andseedling station under the provincial departments of forestry including Heilongjiang, Jilin, Liaoning, Beijing, Hebei, Shandong, Henan, Shanxi, Shannxi, Gansu, Xinjiang, Inner Mongolia, Anhui,Zhejiang, Jiangxi, Hubei, Hunan, Sichuan, Guizhou, Yunnan, Fujian, Guangdong, Guangxi andHainan. In addition, while the book was compiling, Prof. Wu Zhonglun, the academician of theChinese Academy of Science, gave us many valuable comments and advice, so did Mr. LiuXiaozhang, the director of the Department of Science and Technology (DST), Ministry of Forestry(MOF), Mr. Wang Qi, the director of the General Station of Forest Farm and Nursery, MOF, Mr. Zhang Peichang, the deputy director of the Department of Planning, MOF, and Ms. Yang Linmei,the chief of the Division of Planning under DST, MOF. Here, we really like to express our greatfulthanks to the institutions and people mentioned above. Furthermore, we also thank the experts of theSpecialist Committee for the research achievement of regionalization for their appraisal work, suchas, Mr. Wang Qi, the chief of the committee, Prof. Shen Xihuan, the deputy chief of the committee, Prof. Hong Jushang, Prof. Huang Minren, Prof. Pan Benli, Prof. Zhang Shunhong, Prof. XuXiakqing, Prof. Shi Jisen, Mr. Zhou Bing, Prof. Yang Chuanping and Mr. Zhang Peichang.

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The readers are warmly welcomed to give us your comments on any contents of the book forcorrection or improvement.

Research Professor Gu Wanchun

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