

# Atlas of Woody Plants in China

**Distribution and Climate**

**Volume I**

Edited by

Jingyun Fang

Zhiheng Wang

Zhiyao Tang

# **Atlas of Woody Plants in China**

**Distribution and Climate**

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内容提要

准确翔实的物种分布资料是宏观生态学、生物地理学以及保护生物学等学科的研究基础,也是农业、林业生产实践的重要基础。北美、欧洲和日本在 20 世纪七八十年代就出版了详细的动、植物物种分布图,为这些区域的生物地理学、宏观生态学研究以及生物多样性保护实践提供了不可缺少的基础资料。中国是全球 12 个“巨大生物多样性国家”之一,拥有超过 30 000 种维管植物,其中包括约 11 000 种木本植物、3200 种树木,物种数量远高于同处中高纬度的北美洲和欧洲。但中国目前还没有较为完善的植物分布图集。

本图集在忠实于标本记录的基础上,收集了我国目前已出版的全国、各省区和地方植物志、树木志,以及区域科学考察报告和学术论文中有关的木本植物分布资料,并在此基础上邀请全国各地 20 多位专家对现有资料进行修订和补充,最终编制了我国已知的全部 11 405 种木本植物的详尽分布图。图集中的物种名录采用了当前最新的分类系统,与国际标准一致。同时,图集还提供了物种的生活型以及物种分布区的 13 个气候和初级生产力指标,为生态学、生物地理学和保护生物学的基础研究和实践提供了重要的基础资料。

本图集是目前中国第一部具有完整木本植物名录、包含翔实分布信息和气候特征的专著,可作为生态学、植物学、地理学等相关学科的广大师生以及农林科技工作者的参考书。

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# **Atlas of Woody Plants in China**

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# 中国木本植物分布图集

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Jingyun Fang | 方精云

Dr. Jingyun Fang is a Cheung Kong Professor at Department of Ecology, Peking University. He obtained his PhD from Osaka City University (Japan) in 1989. His research interests cover vegetation ecology, biogeography of plants, carbon cycle and the application of remote sensing. He is an author of more than 230 publications including five books. He has received several awards including He-Liang-He-Li Science and Technology Progress Award, Cheung Kong Scholars Achievement Award, and National Natural Science Award of the State Council. He is a member of the Chinese Academy of Sciences and the Academy of Science for the Developing World (TWAS), and serves as the editorial board member for several journals including *Frontiers in Ecology and the Environment*, *Ecosystems*, *Global Environmental Change*, *Science China*, *Ecological Research*, *BMC Ecology* and others.

北京大学长江特聘教授、中科院院士，第三世界科学院院士。1989 年获日本大阪市立大学生物学博士学位。主要从事植被生态学、生物多样性、生态系统碳循环等方面的科研和教学工作。共发表论文 230 余篇，出版专著 5 部。曾获首届国家杰出青年科学基金 (1994)、教育部自然科学一等奖 (2003)，国家自然科学二等奖 (2004)，长江学者成就奖 (2006)，何梁何利科学技术进步奖 (2007) 等奖项以及全国野外科技工作先进个人称号 (2009)。是国内外多个专业杂志的编委或副主编，包括 *Frontiers in Ecology and the Environment*, *Ecosystems*, *Global Environmental Change*, *Science China*, *Ecological Research*, *BMC Ecology*。



Zhiheng Wang | 王志恒

Dr. Zhiheng Wang is a postdoc researcher in Institute of Environmental Sciences, University of Zurich, Switzerland. He got his PhD at Peking University in 2008, and has research interests in all issues of macroecology. He has been working on the Database of China's Woody Plants for the last six years. His recent focus is on macro-scale patterns of species richness, species range size, species body size, patterns in community structure, and the mechanistic causes of such patterns. His current research involves testing the influence of contemporary climate, evolutionary history, human activities, and spatial scale on species diversity patterns using the synthesis of climatic, phylogenetic, and anthropogenic data. He has published 20 papers, including a recent paper in the Proceedings of the National Academy of Sciences, USA.

目前在瑞士苏黎世大学环境科学研究所从事博士后研究。2008 年毕业于北京大学，获理学博士学位。过去 6 年以来一直致力于“中国木本植物分布数据库”的建设。主要从事宏观生态学 and 全球变化生态学研究，内容包括物种多样性、物种分布区、个体大小和群落结构的大尺

度格局及其进化和气候的形成机制，以及气候变化对物种多样性的影响。发表论文 20 余篇，包括一篇美国科学院院刊论文。



Zhiyao Tang | 唐志尧

Dr. Zhiyao Tang is an associate professor at the Department of Ecology, Peking University. He got his PhD at Peking University in 2003. His research interests include plant community ecology, biodiversity patterns, climate-vegetation interaction, and application of remote sensing in ecology. He has authored more than 40 peer-reviewed articles and two books.

北京大学生态学系副教授。2003 年毕业于北京大学，获理学博士学位。主要从事植被植物群落生态学、生物多样性、植被气候关系以及生态遥感等方面的科研与教学工作。发表论文 40 余篇，专著 2 部。

# Preface | 前言

China is one of the earth's 12 mega-biodiversity countries, and the most diverse country in the northern hemisphere. With more than 30,000 species of vascular plants, more than 1/3 of which are woody plants, the number of plant species in China is higher than in Europe and North America combined. However, a comprehensive atlas of the distribution of woody plants in China has not been yet available though atlases of the species distribution in many western countries were compiled several decades ago. For example, an atlas of the United States trees was published in the 1970s. The atlas of vascular plants in Japan with a vertical resolution of 50 m was compiled in the 1970s. A project for mapping distribution of vascular plants in Europe was launched in 1965, and 13 volumes of the atlas have been published to date. These atlases of plants are of both scientific and practical importance, and provide an indispensable database for understanding the patterns and mechanisms of species distribution, utilizing the biological resources, protecting biological diversity, implementing regional development planning, and predicting ecological responses of plants to global environmental changes.

Why has China lacked of such atlas? This might be primarily due to there being too many species and limited information on the distributions of those species. These make some people think that it is not right time to compile the national atlas for China's plants. However, I don't agree with this opinion. Nothing is perfect, especially for the information on species distribution. For example, in 1817, Alexander von Humboldt drew the first isothermal map based on temperature data from only 58 climatic stations globally, which became the basis for climatic division and physiogeographical study for decades. Japan has completed the atlas for all its vascular plants with a vertical resolution of 50 m in the 1970s with limited information on distribution of plants. Compared with these, China has accumulated copious data on plant distribution through the efforts of the several generations of botanists and ecologists over the past half century. These hard-earned data provide an essential base to systematically compile the atlas of China's plants. Therefore, in my opinion, now it is the time to compile the atlas of China's plants, which is an urgent need for the conservation and sustainable use of biological resources.

The idea of compiling the atlas of China's plants initially came into my mind in the mid-1980s when I was a PhD student in Japan. My dissertation was to examine the relationships between climate and vegetation in China and I strongly felt that China was lacking of the species distribution data. I was very impressed when I saw the detailed spatial explicit distribution maps of vascular plants in Japan, and made a copy of the maps of major species and brought them back to China. They are still kept on my bookshelf now. In

1996, I was touched again when I saw the atlas of the United States trees and European species in McGill University, Canada, where I was a visiting scholar. These two shocks made me long hope that we should have an atlas for China's plants in the near future. In 2003 as the first step of compiling an atlas for all the plants of China, we initiated a project to compile the *Atlas for All the China's Woody Plants*, although without specific funds, because distribution information is relatively rich and the checklist is well-documented for the woody plants in China. As the basic data of the atlas, we first started to construct "*Database of China's Woody Plants*". We documented the distribution sites for all the species based on specimen records and all the validated records documented in publications. After six years' efforts, this atlas which documents more than 11,000 woody species was eventually published.

In this atlas, we provide distribution maps for more than 11,000 species at the level of counties. We also documented information on climate, primary production and life forms for each species. This atlas contains information on both species and environmental variables, compared with the previous atlases published in other countries or regions.

As above mentioned, we launched this project without specific financial support. However, we have been lucky to have creative human resources and excellent students, who have been dedicated to the collection and compilation of these basic data, which is difficult to yield articles but is critically significant in scientific research and practical use. Here, I would like especially to mention two major contributors of this atlas, Dr. Zhiheng Wang and Dr. Zhiyao Tang, who took major responsibility to complete the atlas. Zhiheng was my PhD student whose PhD project was to examine patterns of China's woody plants and the mechanisms that shape those patterns. He joined my group in his senior year, and I asked him to postpone his defense for his PhD twice to complete the construction of the database of China's woody plants. For this reason, he stayed in my group as a PhD student for eight years. During this period he led a group of students to overcome many problems that data compilations posed and spent six years and finally completed the database, which makes publishing this atlas possible. Zhiyao donated uncounted hours of his time to collect data, check distribution records, collate species name, design maps, and so on. In addition, many staff and students contributed their time in data collection, data input and species name collation. To all of them, I am grateful.

The atlas was based on many sources of information, including a Chinese version (*Flora Reipublicae Popularis Sinicae*) and English version of "*Flora of China*", and "*Seed Plants of China*" edited by Zhengyi Wu, "*Higher Plants of China*" edited by Liguu Fu, and nu-



merous local flora and species surveying reports. The compilation of this atlas would be impossible without these basic, most essential works. Here, I am greatly indebted to all the authors for their efforts. I would also like to thank the botanists and field biologists who reviewed and corrected the distribution records of species. I want to acknowledge many students in the Department of Ecology, Peking University, who assisted this project by documenting distribution data. Mr. Jin'an Lin and Ms. Li Wang of Higher Education Press (China) spent lots of time editing, collating and publishing this atlas. I will like to express my many thanks for all these people. The compilation of this atlas was partly supported by the National Natural Science Foundation of China (Nos: 40638039,

90711002, 30721140306, 40871030, 40501025, 49971002, 39970044, 39425003).

In spite of our best efforts, errors still remain in this atlas due to our limited knowledge and limited information on species distribution. Please contact us (Email: zytang@urban.pku.edu.cn) and send us your comments so that we can update the atlas in the near future.

*Jingyun Fang*  
Professor of Plant Ecology  
September, 2009

中国是世界上物种多样性特别丰富的国家之一，拥有维管植物约30 000余种，其中1/3以上是木本植物，比北美和欧洲的总和还要多。但中国至今尚没有全面记述这些物种地理分布的图集。这应该说是件十分缺憾的事。早在几十年前，西方国家就已经完成了物种分布图的编制工作。比如，美国于20世纪70年代完成了全美木本植物分布图的编制；日本在20世纪70年代出版了所有维管植物的分布图，物种垂直分布范围的精度达50 m；欧洲也于1965年开始了维管植物分布图的编制工作。这些分布图为揭示物种的分布规律、开发和利用生物资源、开展生物多样性保护、进行区域发展规划，以及预测气候变化的生态影响等提供了不可或缺的基本资料，其科学价值和实践意义是不言而喻的。

为什么中国缺乏这类分布图？物种多、物种分布资料不足又散布于各类文献中，造成了编制工作难度大，这可能是最主要的原因。此外，国内对编制物种分布图的保守认识也是一个重要的限制因素。

据我所知，国内一些人认为，我国物种分布资料不足，目前尚不具备编制植物分布图集的条件。但我不同意这种说法。科学技术的进步是无止境的，大自然的很多现象和规律是逐渐被认知的，否则人类文明就不会进步到今天。1817年洪堡依据全球仅有的58个气象站的气温资料，绘制了世界首张全球等温线分布图，是气候分区和自然地理学研究的一个重要里程碑，成为相当长时期内开展相关研究的基石。又如，日本在30多年前就能出版垂直分布范围高达50 m精度的维管植物分布图，不能说他们当时已经掌握了所有物种准确的分布信息。因此，如果等物种分布资料齐全了才编制其分布图，那我们所待何时？事实上，经过广大植物学家、生态学家半个多世纪的努力，我国的物种分布资料已经有了相当深厚的积累，系统编制物种分布图的时机已经成熟，这也是时代发展的迫切要求。当然，随着知识的积累和认识水平的提高，这类分布图的信息需要进一步补充和完善。

编制中国植物分布图是我在学生时代就萌生的愿望。

早在20世纪80年代的中后期，我在日本读书，博士期间的研究课题就是关于中国植物分布与气候关系的研究，实感中国物种分布数据之缺乏。当我看到日本详尽的物种分布图时，那种欣喜若狂至今还记忆深刻，当时我就不加思索地把主要物种的分布图全都复印了下来，带回国内，至今还保存着。1996年，我去加拿大McGill大学做访问学者，看到美国和欧洲也有详尽的物种分布图，又一次受到触动。于是，就产生了将来我们也要编制中国植物分布图的想法。2003年，在没有专项经费支持的情况下，我们决定先编制分布资料较多、种名相对稳定的木本植物分布图，于是启动了“中国木本植物分布图的编制”自设课题。次年，作为编制物种分布图的基础工作，课题组开始了“中国木本植物分布数据库”的建设。历经6年的艰苦工作，这本多达2 000余页的图集终于与读者见面了。

本图集的特点是为11 405个物种提供县级分布信息；每个物种的分布信息在忠实于标本记录的基础上，最大可能地吸收了所有物种分布研究的成果；提供物种分布区的气候资料和分布区初级生产力的平均状况。此外，我们也提供了绝大多数物种的主要生活型信息。本图集的这些特点，既克服了西方国家仅提供物种分布信息的局限性，也满足了人们对分布区气候和物种生活型等基础信息的需求，使其更具实用性。

前面讲过，我们是在没有专项经费的条件下开始此项工作的。我们虽然没有专项经费，但有丰厚的人力资源，有非常优秀的同学，他们愿意献身于这类发表成果难、但有重要科学和应用价值的基础性数据的收集和整理工作。这里，我要特别提到本图集的两位主要作者：王志恒和唐志尧，他们是本图集的主要贡献者。王志恒当时是我的直博生，我给他的博士论文题目就是中国木本植物多样性的分布格局及其机制的研究。他自大三就进入我的研究组，直到博士毕业，一共呆了8年。为了完成数据库的建设，我两度让他推延博士毕业。他带领一批同学，克服物种多、

物种名称杂乱、物种分布信息零散不全等困难，历时6年，终于建成了“中国木本植物分布数据库”，使本图集的编制成为可能。另一名主要作者唐志尧，在物种分布数据收集、分布区和种名校核、分布图制作与设计、编辑和出版等方面，做了主要的工作。可以说，他们二位是本图集编制出版的主要贡献者。此外，很多老师和同学在数据收集和录入、种名校校等方面也做了大量繁杂的工作。

本图集凝聚了几代人的心血和汗水，它是在中英文版《中国植物志》、吴征镒先生主编的《中国植物分布数据库》所记载的物种名录、傅立国主编的《中国高等植物》以及众多地方植物志和调查报告中所记载的物种分布信息的基础上编制出版的。因此，我要特别感谢这些作者们，没有他们的工作，就没有本图集的出版。北京大学生态学系的多位同学参与了数据的收集、整理和校对，以及

分布图的制作等。数据库建成后邀请各地的有关专家对种名和分布区进行了校验和补充。高等教育出版社的林金安先生、王莉女士为本图集的制作、编辑和出版做了大量艰苦而有成效的工作。在此，对他们表示衷心的感谢。本图集在数据收集、整理和出版过程中，得到国家自然科学基金委的部分资助(编号：40638039, 90711002, 30721140306, 40871030, 40501025, 49971002, 39970044, 39425003)。

由于我们水平有限，以及现有资料的不足，本图集肯定存在一些纰漏，请读者们批评指正(请联系zytang@urban.pku.edu.cn)，以便在修订时改进。

方精云  
2009年9月  
于北京大学

# How to Use This Atlas | 本图集使用说明

## 1 Arrangement of families, genera and species

The order of families, genera, and species were arranged as follows: the families are organized according to the phylogenetic system of *Flora of China*; within each family, the genera and species are arranged alphabetically. The atlas is published in three volumes, plus a separate volume of species checklist.

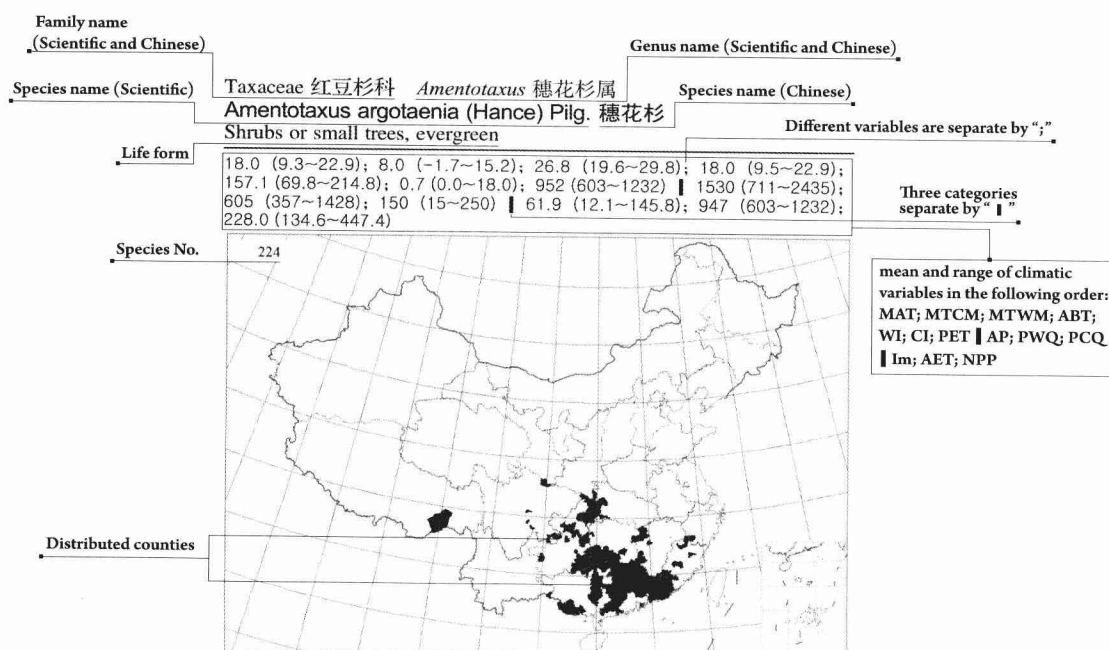
## 2 Arrangement of the climatic variables

The atlas lists mean and range of 12 climatic variables and vegetation net primary productivity. They are: mean annual temperature (MAT, °C), mean temperature of the coldest month (MTCM, °C), mean temperature of the warmest month (MTWM, °C), annual biotemperature (ABT, °C), warmth index (WI, °C), coldness index (CI, °C), potential evapotranspiration (PET, mm), annual precipitation (AP, mm), precipitation of warmest quarter (PWQ, mm), precipitation of coldest quarter (PCQ, mm), moisture index (Im), annual actual evapotranspiration (AET, mm), vegetation net primary productivity (NPP,  $\text{g} \cdot \text{a}^{-1} \cdot \text{m}^{-2}$ ). For those

species distributed in less than five counties, only the mean values of the climatic variables are listed. To save space, names of these variables and their units are not showed in the illustration of each species; these variables are listed as the following order, and three categories of variables (thermal index, humid/arid index, and integrative index) are separated by mark “■”.

MAT (°C); MTCM (°C); MTWM (°C); ABT (°C); WI (°C); CI (°C); PET (mm) ■ AP(mm); PWQ(mm); PCQ(mm) ■ Im; AET (mm); NPP ( $\text{g} \cdot \text{a}^{-1} \cdot \text{m}^{-2}$ )

The following illustration explains the content of each map, using *Amentotaxus argotaenia* (Hance) Pilg. as an example. Following the illustration, MAT is 18.0 °C (Range is 9.3~22.9 °C); MTCM 8.0 °C (−1.7~15.2 °C); MTWM 26.8 °C (19.6~29.8 °C); ABT 18.0 °C (9.5~22.9 °C); WI 157.1 °C (69.8~214.8 °C); CI 0.7 °C (0.0~18.0 °C); PET 952 mm (603~1232 mm) ■ AP 1530 mm (711~2435 mm); PWQ 605 mm (357~1428 mm); PCQ 150 mm (15~250mm) ■ Im 61.9 (21.1~145.8); AET 947 mm (603~1232 mm); NPP 228.0  $\text{g} \cdot \text{a}^{-1} \cdot \text{m}^{-2}$  (134.6~447.4  $\text{g} \cdot \text{a}^{-1} \cdot \text{m}^{-2}$ ).



1 科、属、种排列说明

本图集科、属、种排列顺序如下：科序按 *Flora of China* 系统排列；科内（属、种）按字母顺序排列。本图集分三册出版，并附种名索引一册。

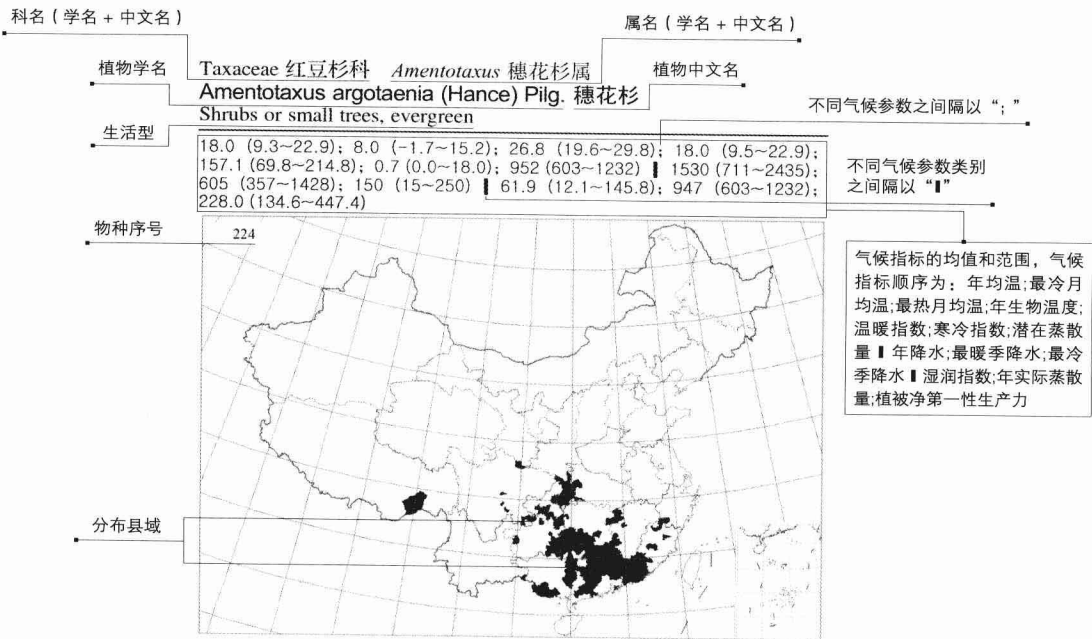
2 气候指标表示方法及使用说明

本图集给出每个种分布区的 12 个气候变量和植被净生产力的均值和范围。这些指标的意义和计算见第 xxvi~xxvii 页说明。对于分布区小于 5 个县域的物种，我们仅列出各气候指标的均值。为节省空间，这些指标按以下顺序给出，并在各类气候指标（温度指标、水分指标和水热综合指标）之间间隔以“■”符号。另外，各指标都省去单位。顺序（含单位）如下：

年均温（℃）；最冷月均温（℃）；最热月均温（℃）；

年生物温度（℃）；温暖指数（℃）；寒冷指数（℃）；潜在蒸散量（mm）■年降水（mm）；最暖季降水（mm）；最冷季降水（mm）■湿润指数；年实际蒸散量（mm）；植被净第一性生产力（ $\text{g} \cdot \text{a}^{-1} \cdot \text{m}^{-2}$ ）

以穗花杉 [*Amentotaxus argotaenia* (Hance) Pilg, 红豆杉科 *Taxaceae*, 穗花杉属 *Amentotaxus*] 为例，用下面的示意图说明分布图及气候指标的含义。穗花杉在其分布区的气候指标（平均值和范围）如下：年均温为 18.0℃（范围 9.3~22.9℃），最冷月均温 8.0℃（-1.7~15.2℃），最热月均温 26.8℃（19.6~29.8℃），年生物温度 18.0℃（9.5~22.9℃），温暖指数 157.1℃（69.8~214.8℃），寒冷指数 0.7℃（0.0~18.0℃），潜在蒸散量 952 mm（603~1232 mm）■年降水 1530 mm（711~2435 mm），最暖季降水 605 mm（357~1428 mm），最冷季降水 150 mm（15~250 mm）■湿润指数 61.9（12.1~145.8），年实际蒸散量 947 mm（603~1232 mm），植被净第一性生产力 228.0  $\text{g} \cdot \text{a}^{-1} \cdot \text{m}^{-2}$ （134.6~447.4  $\text{g} \cdot \text{a}^{-1} \cdot \text{m}^{-2}$ ）。



# 1

## Introduction to the Compilation of This Atlas

### 中国木本植物分布图编制说明

#### 1.1 Construction of “Database for Distribution of Woody Plants in China”

Accurate data for distribution ranges of species are fundamental in the study of macroecology and biogeography. In the past several decades, detailed range maps of vascular plants and terrestrial vertebrate animals (birds, mammals, amphibians and reptiles) have been published for North America, Europe and Japan, and these data have been widely used for the studies on patterns of species diversity and spatial turnover, and other large-scale ecological patterns (Brown, 1995; Brown & Lomolino, 1998).

China is one of the world's “mega-biodiversity countries” (McNeely *et al.*, 1990), harboring more than 30,000 vascular plants, of which c.a. 11,000 species are woody plants, including c.a. 3200 trees. These numbers follow Brazil and Columbia (Chen *et al.*, 1998), and are substantially higher than North America and Europe (Li, 1952; Latham & Ricklefs, 1993). Nonetheless, no comprehensive and accurate databases are available for the plant distributions in China yet.

In the past century, a great deal of field surveys, such as key comprehensive projects of the Tibetan Plateau, Hengduan Mountains, and the Three-Gorge Region, have been conducted in China. These field surveys have accumulated enormous amounts of data on plant distributions. Numerous national floras, including “*Flora Reipublicae Popularis Sinicae*” (volume: 1-80), *Flora of China* (volume: 1-25), “*Sylva Sinica* (volume: 1-4)”, “*Higher Plants of China* (volume: 1-14)”, and “*Vegetation Atlas of China: 1:1,000,000*”, have been published, together with dozens of provincial and local floras and checklists. These have provided essential data for the construction of databases about distributions of plants in China.

As woody plants have been relatively intensively investigated, we initiated a project to compile maps for “*China's woody plants*” in 2003, and dozens of local experts had been invited to check and correct the information in the database. The database was completed in the late 2008. It contains the distribution of all 13,570 woody plants (including variations and subspecies), which are defined as vascular plants with xylem in roots and stems, including trees (height > 4m), shrubs (height < 4m) and woody vines (Wu, 1980). However, the number of species was changed to 11,405 following newly-

published “*Flora of China*” (English version) and “*Catalogue of Life, China: 2008 Annual Checklist*”. Therefore, this database documents all these 11,405 species. The database is the most comprehensive and up-to-date document for the distribution of woody plants in China. It provides Chinese and scientific names, a distribution map for each species, as well as the climatic conditions for the distribution area of each species.

#### 1.2 Processes to construct the database

The database was constructed by the following four steps:

First, a checklist for China's woody plants was documented based on species names and the phylogenetic system of “*Flora Reipublicae Popularis Sinicae*” (Volume 1-80) (*Flora Reipublicae Popularis Sinicae* Agendae Academiae Sinicae Edit, 1959-2006) and “*Seed Plants of China*” (Wu and Ding, 1999). All cultivated species were excluded from this checklist. The “*Flora Reipublicae Popularis Sinicae*” is the product made by more than 450 well-qualified Chinese taxonomists over the past 50 years, and is used national wide and worldwide. The “*Seed Plants of China*” is completed by a number of Chinese leading taxonomical experts over 10 years, led by Prof. Zhengyi Wu (a world-class taxonomist and the co-chief-in-editor of the “*Flora of China*”). Based on these two major sources, we documented a checklist of China's woody species. In order to improve the quality of the checklist, several well-known taxonomists were invited to further check the checklist. During the establishment of the database, the *Flora of China* (Volume 1-25) (Editorial Committee of *Flora of China*, 1994-2008), which is the revised and English version of “*Flora Reipublicae Popularis Sinicae*” was published, and the “*Catalogue of Life, China: 2008 Annual Checklist*” (Species 2000 China's Node, 2008, available at <http://www.sp2000.cn/>) was released. We followed these two to update the checklist. In total, 11,405 woody plants (including 1,355 variations and subspecies) from 1,175 genera and 170 families are documented in our database.

Second, we documented information on county-level distribution for each species using all the available literature, such as national, provincial, and local floras and checklists, monographs of field campaign for plants, and articles, as well as specimen distribution records (<http://www.cvh.org.cn>). We also provided life



forms for most species according to published literatures.

Third, we invited 21 local experts in the area of botany and ecology to improve and correct information on species distribution and Chinese and scientific names of species, genera and families for each species from all the regions.

Fourth, using Visual Basic language and MapObject (ESRI Int.), we developed a software for the management of the database. As illustrated in Figure 1, the interface of the software provides basic functions for the database management, for example, data edition/modification, indication of distribution ranges of species, data input/output, searching and printing.

The database provides the information on the county-level distribution for the woody plants (Figure 2). China has 2,408 (based on the data from 1998) counties; the county area is greatly right skewed (skewness = 9.93, median area = 2,081 km<sup>2</sup>), suggesting that a few counties are large but most counties are very small. Large counties are all located in Tibetan Plateau and Taklimakan Desert, where species richness is very low due to extremely arid and/or cold environment. In order to improve the precision of species distribution, we divided these large counties into several parts to document the distribution range for each species.

### 1.3 Special notes on the atlas

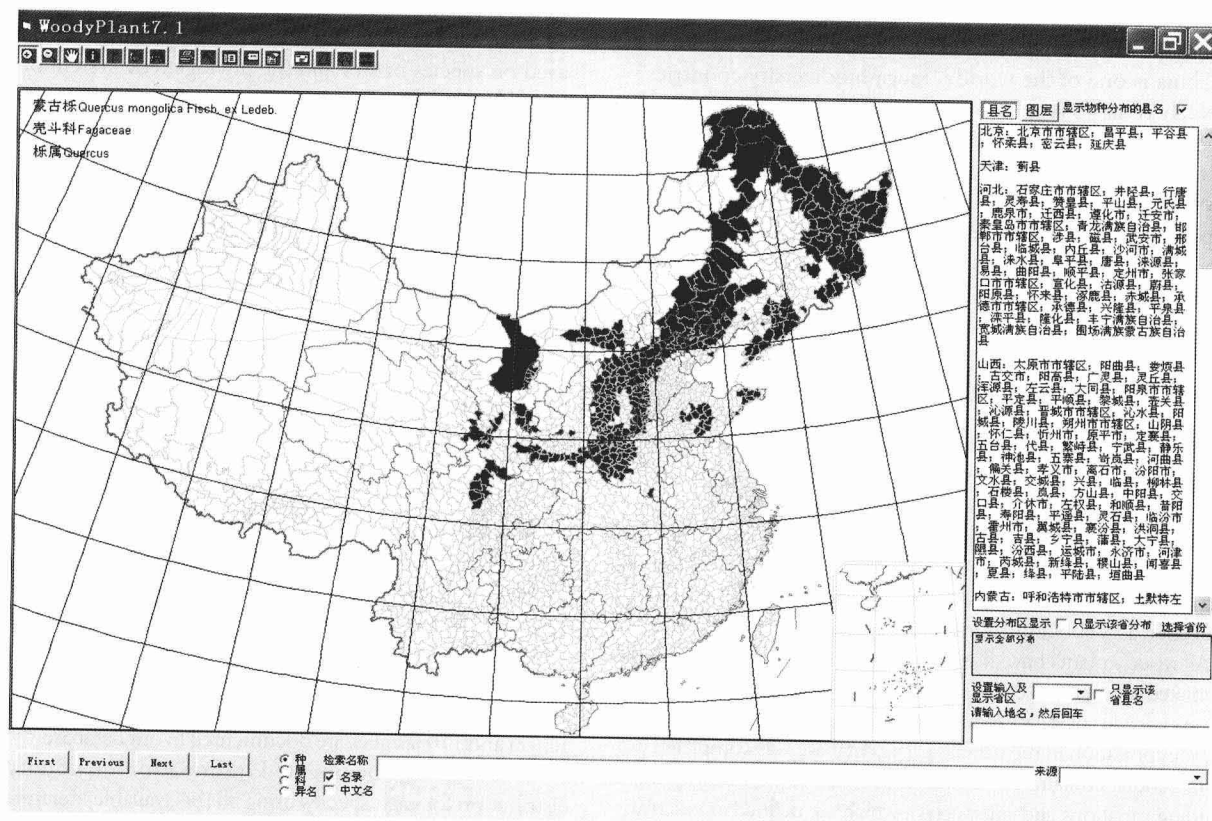
(1) The information on species distribution in this atlas was documented primarily based on specimen records, as well as valid provincial and local floras, investigation reports and research articles,

and knowledge of local experts. Thus, the distribution ranges in this atlas are somewhat conservative, as we used only the evident records of the distribution.

(2) According to the species distribution-range theory and niche theory, a species can occur in all the counties with the similar habitats within its distribution range. However, we did not add the counties which lack evident records of distribution to the distribution range of the species. Thus, some species are distributed sporadically and disjunctly in China, such as *Fagus hayatae*.

(3) Some species occur in a large area, but in some cases that species might not have been documented in a few counties in the area. In this case, we determined if these counties were in their distribution area by checking if the topographic and climatic conditions of these counties are similar to their surrounding counties (with evident records of distribution). If yes, we took these counties as the distribution sites.

(4) Basically we document natural distribution range for all the species in the atlas. However, for some important and widely cultivated economic plants (such as *Ginkgo biloba* and most fruit trees), the natural and cultivated distribution range are not clear because of the long history of cultivation, and therefore the distribution range of the species in the atlas may not be natural. For example, according to *Flora of China*, *Ginkgo biloba* is only naturally distributed in the Mt. Tianmu, Zhejiang Province. However, it has been now planted all over China, and in most countries in the Northern Hemisphere. In this case, the readers should be careful to take the information on the distribution of this species.



**Figure 1** The interface of the software for "Database of China's Woody Plants". Using the interface, we can conveniently search and illustrate the distribution ranges of species, print range maps, input new data and edit the data in the database.

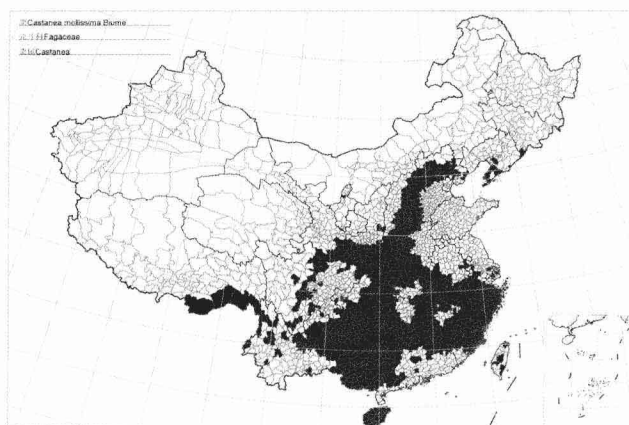


Figure 2 Distribution of *Castanea mollissima* in China.

(5) We provided climate information in this atlas for all the species, which is useful to understand the distribution and conservation of the species.

(6) We emphasize here again that there may be some incorrect information in this atlas because of a huge number of species and the limited information for some species. However, this will not prevent it from ecological and practical applications for the most cases.

## 1.1 “中国木本植物分布数据库”的建设

准确的物种分布信息是宏观生态学 (macroecology) 和生物地理学 (biogeography) 研究的重要基础。在过去的几十年中, 随着物种分布资料的积累以及大量物种分布图的出版, 基于物种分布区资料研究物种丰富度、物种组成更替以及其他生态格局已经成为宏观生态学和生物地理学中的通用方法 (Brown, 1995; Brown & Lomolino, 1998)。北美、欧洲和日本在几十年前就出版了详细的动、植物物种分布数据集或分布图, 为这些区域的生物地理学和宏观生态学研究提供了不可缺少的基础资料。

中国是全球 12 个“巨大生物多样性国家”之一 (McNeely *et al.*, 1990), 拥有超过 30 000 种维管植物, 其中包括约 11 000 种木本植物、3 200 种树木, 物种数量仅次于位于南美洲的巴西和哥伦比亚, 位居全球第三 (陈昌笃等, 1998), 而远高于同处北温带的北美洲和欧洲地区 (Li, 1952; Latham & Ricklefs, 1993)。但中国目前还没有一个较为完善的植物分布数据库。

在过去的一个世纪中, 中国的植物学家和生态学家对植物的分布进行了广泛调查, 开展过多次大型科学考察, 比如青藏高原考察、横断山区考察、三峡地区植物资源考察等, 积累了大量的第一手资料。最近二十年来, 《中国植物志》、《中国树木志》、《中国植被图集: 1:100 万》以及多个省区的植物志和树木志相继出版; 一大批地方植物志和植物资源考察报告也纷纷出版发行。这为建立中国植物分布数据库提供了不可或缺的基础资料。考虑到木本植物分布资料较多、种名相对稳定, 我们自 2003 年开始, 先期组

织实施了“中国木本植物分布数据库”建设项目, 并邀请全国各地熟知当地植物分布的专家数十人参与物种分布区数据的校验。该数据库于 2008 年底建成, 它收录了我国已知的全部木本植物, 共包括 13 570 种 (包括变种、亚种和变型)。后按英文版《中国植物志》和“中国生物物种名录 2008 版”, 对物种进行了归并, 最终收录 11 405 种木本植物, 是目前最为完善和全面的中国木本植物分布数据库。数据库中, 木本植物是指根和茎含有木质部的植物, 包括乔木 (高度 > 4 m)、灌木 (高度 < 4 m) 和木质藤本植物 (吴征镒, 1980)。数据库包含了每种植物的中文名称、学名及其在中国境内的县级分布。

## 1.2 数据库编制过程及数据形式

数据库的建设主要包括以下四个步骤:

首先, 以《中国植物志》和“中国种子植物数据库”为基础, 建立中国木本植物名录, 其分类系统参考《中国植物志》(共 80 卷 125 册, 中国植物志编委会, 1959–2006), 所有栽培种排除在外。《中国植物志》是超过 450 名中国植物学家近 50 年工作的积累, 是国内外公认的有关中国植物最为权威的图志。“中国种子植物数据库”是由吴征镒院士领导、大量植物分类学家共同经过 10 多年工作的成果。在这两个数据源的基础上, 我们建立了中国木本植物名录, 并邀请国内有关分类学家进行校订。在数据库构建期间, 英文版《中国植物志》“*Flora of China*” (1–25 卷) (Editorial Committee of *Flora of China*, 1994–2008) 陆续出版, 以及全球“物种 2000”组织 (<http://www.sp2000.org/>) 在中国节点发布了“中国生物物种名录 2008 版” (Catalogue of Life, China: 2008

Annual Checklist)。为了体现最新成果,我们采用了“*Flora of China*”中的物种名录及分类系统,对异名按照“中国生物物种名录 2008 版”对应的物种进行合并。本名录共包含了 11 405 种木本植物(含 1 355 个种下单位),隶属于 170 科的 1 175 属。

第二,广泛收集物种分布信息,建立每个物种的分布区。物种分布信息参考了目前中国已出版的全部植物志,包括《中国植物志》各卷册以及其他全国性植物志(如《中国高等植物》,傅立国主编)、各省植物志和区域植物志,同时参考了已出版的《中国树木志》和各省树木志、木本植物名录、各个区域的植物资源考察和调查报告以及部分期刊上发表的文章。

第三,为了确保数据库的准确性和权威性,将全国划分为 20 个区域,在不同地区邀请 1~2 名熟知植物分布的植物学专家(共 21 位专家),对数据库中每个物种的分类信息(包括物种中文名、学名及所属科、属信息)以及地理分布信息进行校验、补遗和审定,最终完成数据库。

第四,为便于数据库的管理,使用 Visual basic 以及 MapObject 等工具开发了一款使用便捷的工具软件,其界面如 Figure 1 所示。该界面方便地实现了对物种分布数据库的编辑、修改、浏览显示、输入输出以及搜索等功能。

该数据库提供以县为分布单元的物种分布区(Figure 2)。中国共有 2 408 个县(1998 年资料),各县的面积呈现极度的右偏分布(skewness=9.93),绝大多数县的面积较小,全部县的面积中值为 2 081 km<sup>2</sup>,而青藏高原和塔克拉玛干沙漠以东地区 2 230 个县面积的中值仅 1 864 km<sup>2</sup>;面积较大的县集中在新疆南部塔克拉玛干沙漠周边地区以及青藏高原北部高原腹地。在确定物种分布区时,为了减小这些面积较大的县对于物种分布区精度的影响,我们根据这些县的地形特征以及植被的分布,将每个县细分为几部分。由于特殊的环境条件(极干荒漠以及 4 000 m 以上的高原腹地),这些区域内的物种数量很少,因而这种处理对数据库整体的分布精度影响很小。

下几点需要特别说明:

(1) 本图集给出的物种分布区是在忠实于标本记录的基础上,参考地方植物志、植物资源调查报告和相关研究论文等资料,结合各地专家的实践经验确定的。所以,本图集给出的分布区信息应该是偏保守的。

(2) 按照物种分布区理论和生态位理论,一个物种在其分布范围,具有相似生境的区县都有可能是其分布区。但在确定该物种的分布地点时,如果没有充分的证据,本图集并没有将那些缺乏分布记录但生境相近的区县划成分布区。同样,不少物种在其分布区内,存在明显的零星或隔离或间断分布(如台湾水青冈是间断分布的典型例子)。本图集忠实于文献记录,对其分布区未作增减。

(3) 一些物种的分布图会出现这种情况:周围地区有该物种分布的记录,但中间少数区县没有分布记录。对这类情况,本图集对照地形图和气候信息,决定是否增补这些空白区县为分布区。这种处理带有一定的主观性。

(4) 本图集给出的物种分布基本反映自然分布,但某些重要经济和药用植物(如银杏和大多数有重要经济价值的果树等),由于其栽培历史悠久,自然分布区和栽培分布区难以分辨。例如,据记载,银杏仅在我国浙江天目山有野生分布,但它现已在我国大部分地区和北半球大多数国家都有栽培。在这种情况下,分布区的概念已经失去其原有的意义,不仅难以界定其精确的分布范围,其意义也不大。因此,我们所给的分布区仅供读者参考。

(5) 本图集提供的气候信息很重要,也基本准确,即使对那些分布区不连续的物种来说,本图集给出的气候指标也能够基本反映该物种的气候特征。

(6) 再次强调,由于中国木本植物种类多,分布信息不足,本图集一定会有这样或那样的问题,但编制其分布图是时代发展的迫切需要,不能再等了。我们已经落后于其他主要国家几十年了。

### 1.3 图集编制的几点说明

“中国木本植物分布数据库”建设及分布图编制时,以



## 2

# Characteristics of Distribution of Woody Plants in China

## 中国木本植物分布的基本特征

### 2.1 Composition of woody plants

China has 11,405 woody species, belonging to 1,175 genera and 170 families, of which, 6,735 (59.5%) are shrubs, belonging to 754 genera and 142 families; 3,165 species (27.8%) are trees, falling under 498 genera and 107 families; and 1,035 (9.1%) are woody vines, falling under 176 genera and 49 families; and 470 are bamboos, falling under 33 genera and 1 family (Table 1).

The numbers of woody species of gymnosperms, dicotyledons, and monocotyledons are 244 (2.1%), 10,480 (91.9%) and 664 (5.8%), respectively (Table 1). The woody monocotyledon species are mainly composed of bamboos (Gramineae) (470 species), liliaceous shrubs (Liliaceae) (93 species) and palms (Palmae) (89 species).

According to the definition of biogeographic types for plant families in China proposed by Wu *et al.* (2003), we divided all woody species into three categories according to their families:

cosmopolitan, tropical, and temperate species. Nearly half (46.1%) of woody plants are tropical species, whereas the proportions of temperate and cosmopolitan species are 19.8% and 33.9% respectively (Table 1). China has only two endemic woody plant families, Eucommiaceae and Ginkgoaceae.

The frequency distributions of species/genus numbers per family, and species numbers per genus are all significantly right skewed (Figure 3), suggesting that most families/genera have a few species (small families and genera), whereas only a few families/genera have many species (large families and genera). More than one third of families have fewer than 10 species, and 24 families are represented by only a single species. Thirteen families (7.6%) have more than 200 species. The top five largest families are Rosaceae (947 species), Ericaceae (845 species), Fabaceae (682 species), Lauraceae (477) and Poaceae (470) (Table 2). The skewness of frequency distribution for species numbers per genus is much larger than that of species/genus numbers per family (skewness 11.1 vs. 3.5 and 3.7) (Figure 3). Four hundred and fifty genera (38.3%)

Table 1 Composition of woody plants in China

Group	No. of Species / %	No. of Genera	No. of Families
<b>Woody plants</b>	<b>11,405 / 100</b>	<b>1,175</b>	<b>170</b>
Trees	3,165 / 27.8	498	107
Shrubs	6,735 / 59.0	754	142
Woody vines	1,035 / 9.1	176	49
Bamboos	470 / 4.1	33	1
Ferns	17 / 0.1	5	3
Gymnosperms	244 / 2.1	35	10
Dicotyledons	10,480 / 91.9	1,076	150
Monocotyledons	664 / 5.8	59	7
Cosmopolitan	3,867 / 33.9	371	25
Temperate origin	2,259 / 19.8	134	44
Tropical origin	5,258 / 46.1	663	96