



北京林业大学经济管理学院

“英才计划”出版工程

编委会主任：陈建成

主编：温亚利 张卫民

# 中国主要木质林产品 虚拟水测算和虚拟水贸易研究

STUDY ON THE VIRTUAL WATER CONTENT  
AND VIRTUAL WATER TRADE OF CHINA'S MAIN WOODY FOREST PRODUCTS

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# 出版说明

## Publication Introduction

为加强学院科研团队建设,培养经济管理青年英才,扩大学院学术交流和学术影响,产出高水平标志性成果,促进学院重点学科与基础学科的协调发展,全面提升学院整体学术竞争力和影响力,北京林业大学经济管理学院制定了“英才计划”,该计划由“创新团队工程”、“出版工程”、“奖励工程”和“论坛工程”四个建设项目组成。

“英才计划”出版工程是对学院教师完成的,以农林经济管理学科领域为主、包括学院其他学科领域中的具有重要理论意义或重大应用价值及前景,或具有独到见解或新颖体系,对科学发展有重要作用的专著出版提供资助,目的是鼓励学术创新、传播学术思想、加强学术交流、繁荣学术研究、促进学术研究更好地服务社会。

“英才计划”出版工程得到了北京东方园林股份有限公司副总经理梁明武、湖南省汨罗市长江铜业有限公司董事长余方然以及中国林业出版社的大力支持,特此鸣谢!

School of Economics and Management(SEM) of Beijing Forestry University (BFU) launched Cultivating Talents Programs including Innovation Team Project, Publication Program, Award Program and Forum Project, which aims to enhance the research team of school, to cultivate young faculties in economics and management to output high level benchmark achievement.

Cultivating Talents Program-Publication Program provide support to manuscript with significance or critical application value or prospective, or with original idea or innovative system mainly agro-forestry economics and management field and other fields completed by school faculty members

Publication Program acknowledge the great support of Mr. Liang Mingwu ( Vice president of Beijing Oriental Garden Shares Co. Ltd), Mr. Yu Fangran (Chairman of Changjiang Copper Product Co. Ltd in Miluo city) and China Forestry Publishing House.

北京林业大学经济管理学院  
“英才计划”出版工程编委会  
2011年5月10日

# 序 言

多年来,北京林业大学经济管理学院以建设和培育国家重点学科——林业经济管理学科为目标,抢抓机遇,深化改革,瞄准学科发展前沿,凝聚全院师生智慧,激发一切可利用资源的活力,团结一致,与时俱进,精思厚德,以人为本,科学发展,敢为人先,在教学、科研、人才培养和社会服务诸方面取得了显著进步。仅2010年,学院在高层次科研项目数量、科研经费总量、高质量学术论文数量、学生获奖层次、本科教学质量评价、专业学位建设等6方面实现突破,创学院历史最好成绩。2010年学院获得国家自然科学基金、国家社科基金和教育部人文社科基金等国家级课题7项;被SCI、EI和ISTP三大检索系统检索的论文共33篇;学院教师获全校理论课教学质量评价第一名;学院学生获“全国先进班集体”称号和58项省级以上学科竞赛奖;学院新增工商管理硕士(MBA)、应用统计硕士、会计硕士、国际商务硕士四个专业硕士学位授权学科点。这些成绩的取得,为学院的改革和发展奠定了良好的基础。

为了进一步推动学院在“十二五”期间快速发展,从2010年起,学院计划用五年时间,在全院推进“英才计划”建设项目。该计划包括“创新团队工程”、“出版工程”、“奖励工程”和“论坛工程”四个建设工程。“创新团队工程”旨在林业经济管理重点学科和其他具有优势和潜力的学科领域,以突出重点团队建设及领军人才培养、突出高水平标志性成果产出为原则,组建学术研究团队,择优提供研究费用资助。“出版工程”旨在鼓励学术创新、传播学术思想、扩大学术影响,资助学院教师多出具有影响力的学术专著。“奖励工程”旨在引导和激励教师申报高层次科研项目、产出高水平学术成果,鼓励教师关心学院发展、积极投身学院教学和科研工作,对在科研、教学和学院发展中取得突出成绩的教师进行奖励。“论坛工程”旨在营造学术氛围、加强学术交流、凝聚学术智慧、扩大学术视野、提倡学术创新,举办各种形式的学术论坛。

“出版工程”作为“英才计划”的重要组成部分,其实施范围在兼顾学院各学科领域的基础上,适当向林业经济管理学科领域倾斜。众所周知,林业经济管理学科在国家生态建设、低碳经济发展及现代林业体系构建中承担越来越重要的人才培养及科学研究责任。北京林业大学林业经济管理学科作为全国同类学科中唯一的国家重点培育学科,在林业经济理论研究方面长期积累,形

## 序 言

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成具有中国特色的林业经济管理学术体系,在林业经济管理学科发展,以及参与国家林业重大问题、前沿和热点问题研究中发挥了积极作用。为促进学科发展,提升学科服务于社会发展的水平,北林林业经济管理学科正努力开展林业经济理论系统研究,以及林业经济重大问题的持续研究,尝试对中国林业经济发展进行理论与实践的梳理和总结,更好地为中国林业发展发挥理论指导作用。

“英才计划”出版工程项目将系统、全面地向社会介绍北林林业经济管理学科及相关学科领域最新的研究成果。主要涉及林业经济管理基础理论,林业经济重点和热点问题,国内外林业经济与政策比较,以及经济学、管理学和政策学最新研究成果在林业上的应用等方面。这些著作中既有青年教师在博士学位论文基础上形成的最新著作,也有教师最新科学研究成果。该出版工程不求研究内容及形式的系统性和完整性,更注重创新性及探索性;特别是对于新时期中国林业发展与社会经济可持续发展关系、林业在应对全球气候变化中的经济与生态环境政策、当前中国改革与发展中涉及林业与生态环境的关键经济政策问题的创新性研究给予高度重视。

这些著作大多是我校经管院中青年林业经济工作者的研究成果,在学术上可能还有不尽完善之处,一些问题在学术界可能也有不同观点,我以为,实施该出版工程的根本目的是繁荣中国林业经济管理研究,鼓励学术创新,勇于探索林业经济重大问题,更好地为中国林业经济发展服务,同时使有志于中国林业经济研究的广大中青年林业经济工作者有机会发表自己的成果,与学术界交流、沟通和争鸣,提升他们的学术水平,为中国林业发展奠定人才基础。

北京林业大学校长

**宋维明**

2011年5月16日

# Foreword

Over the years, School of Economics and Management (SEM) of Beijing Forestry University (BFU) has made a great progress with an aim of building and fostering the national key discipline - forestry economics and management. We seize the opportunity, deepen the reform, aiming at the development of frontier subjects and gather all the wisdom and inspire all available resources and energy of teachers and students. We realize a scientific development, going forward with the times and people-oriented in teaching, research, personnel training and social service. In 2010, SEM got a breakthrough of history because we got 7 major projects from National Natural Science Foundation project, the National Social Science Fund and the Ministry of Education, Humanities and Social Science Fund and other national projects. About 33 papers were cited by SCI, EI and ISTP, with students winning the National Advanced Course Collective and more than 58 provincial level of academic competition awards. Four new programs of graduate studies were approved including Master of Business Administration (MBA), Master of Applied Statistics, Master of Accounting, Master of International Business. All the above achievements have laid a good foundation for the reform and development of SEM.

In order to further promote the development of college in the Twelfth Five-Year Period, from 2010, the college plans to use five years to promote Cultivating Talents Programs. The plan includes Innovation Team Project, Publication Program, Award Program and Forum Project. Innovation Team Project aims to focus on economic management in forestry and other disciplines which have advantages and potentials to highlight the building of the key leader in team and personnel training, highlighting the high level output of the principle of the landmark achievements and provide funds to the formation of research teams in the selection of the best research. Publication Program is to encourage academic innovation, disseminate of academic thinking, and expand academic impact of SEM by funding the publication of academic achievements made by teachers. Award Project aims to guide and encourage the teachers to apply for high-level scientific research projects, and academic achievement of high level, encourage teachers to care about development of the institute by taking an active part in university teaching and research work. Forum Project aims to create academic atmosphere, strengthen academic exchanges and combine academic intelligence by expanding academic horizons and holding various forms of academic forums.

Publication Program is an important part of Cultivating Talents Programs, which will put emphasis on economic management disciplines with the scope of all various disciplines in SEM. As we all know, forestry economics and management assumes an



increasingly important responsibility for personnel training and scientific research in the national ecological construction, low-carbon economic development and construction of modern forestry system. Forestry economics and management of BFU, as the only nation greatly supported in all similar universities, has formed an academic system of the forestry economy with Chinese characteristics with long-term accumulation, and played an active role in the development of economic management disciplines and participation in national forestry major issues and hot issues of frontier. To promote academic development and enhance academic services to the community, economics and management disciplines of BFU are working to carry out systematic study on forestry economic system theory and continuous study on major forestry economics issues, trying to summarize and sort out the Chinese forestry economic development in both theory and practice to play a better role in guiding the development of forestry in China.

Publication Program will make a comprehensive introduction of the latest achievements in forestry economics and related disciplines to the society, including forestry management based on economic theory, economic priorities and hot issues in forestry, domestic and international comparison of forestry economics and policy, as well as economics, management and policy studies on the latest academic achievements in the forestry aspects of the application. All of these works include the latest work based on doctoral thesis of young teachers and the latest scientific research of teachers of SEM.

The publication does not seek a systematic integrity in the content and form, just to put more on innovative and exploratory research, particularly focuses on the relationship of forestry development in new period and sustainable economic and social development, including the global climate change in response to the economic and environmental policies, China's current reform and development related to forestry and ecological environment, etc.

These works are mostly works of young research workers in forest economics of SEM of BFU. They may not be quite complete and there may be different point of view in the academia, but our purposes are to make the research of forestry economics more prosperous, encourage academic innovation, the courage to explore major issues of forestry economy and better economic development of China's forestry services, which will give chances to young researchers in forestry economics to publish their achievements, and push the exchanges and communication and contention to improve their academic standards for laying a base of talents for forestry development in China.

President of Beijing Forestry University

**Song Weiming**

May 16, 2011

# 前 言

随着全球经济发展和人口剧增，水资源已逐渐成为影响世界发展的重要战略要素之一。1993年，由英国伦敦大学 Tony Allan 教授提出并发展的虚拟水理论，为全球水资源平衡、提高水资源利用效率、缓解水资源短缺提供了新思想和新途径，引起了相关领域诸多学者和专家的广泛关注。中国是全球人均水资源量最贫乏的国家之一，水资源已越来越成为制约中国发展的重要因素。因此研究虚拟水理论和贸易、实施虚拟水战略对解决中国严重的缺水问题和促进中国国民经济的全面发展具有重要意义。国内外农产品领域的虚拟水相关研究比较成熟，农产品虚拟水量化研究也有比较完备的模型，但是，林产品作为特殊的水密集型产品，同时存在巨量的国际贸易，相关领域的虚拟水量化以及虚拟水贸易却鲜有研究。

木质林产品来自于森林，对木质林产品虚拟水的研究是建立在森林虚拟水研究基础之上的。本著作在分析森林与水之间关系的基础上，对森林虚拟水含义进行了界定，指出森林虚拟水是指生产“森林”时耗用的水资源量，提出森林虚拟水是一个累积的耗水量，要考虑森林的水源涵养作用。通过对森林虚拟水的构成分析，提出森林虚拟水主要是指森林生长过程中蒸发散作用耗费的水资源量，由土壤蒸发耗水量、林冠蒸发耗水量、林木蒸腾耗水量组成。本著作归纳总结了影响森林虚拟水的内外部因素，认为气候条件、地理环境条件、森林自身条件是影响森林虚拟水的三个方面，其中每个条件都包含许多因素。影响森林蒸发散的因素十分复杂，多种因素交织在一起，相互影响相互作用。限于数据缺乏，本著作在分析总结了森林蒸发散和森林蒸腾量的关系、不同树种森林蒸腾耗水量的特点基础上，采用替代法，用森林蒸腾耗水量来推算森林蒸发散耗水量，运用数学模拟方法以针叶林和阔叶林的代表性树种对针叶林和阔叶林两大森林类型进行森林虚拟水含量计算。本著作是首次提出森林虚拟水的定义和测度理论，并实际对森林虚拟水进行了测算。

本著作采用“生产树法”，对原木（包括针叶原木和阔叶原木）、锯材（包括针叶锯材和阔叶锯材）、木质人造板（包括单板、胶合板、刨花板和纤维板）以及以木材为原料的木浆、纸和纸板等主要木质林产品单位虚拟水含量进行了测算。木质林产品虚拟水的含量是由原料（木材及其他）包含的虚拟水量和林

## 前 言

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产品加工过程耗水量两部分组成,其中木材原料包含的虚拟水量占有绝大部分。林产品加工过程耗水量包括加工过程实际耗水量和能耗所含虚拟水量。研究结果显示:木浆单位产品虚拟水含量最高,在人造板中,胶合板单位产品虚拟水含量最高。总体来看,阔叶类林产品比针叶类林产品虚拟水含量高。由于中国制造木浆的主要原料是阔叶木,造成中国木浆以及由其加工形成的纸和纸板单位产品虚拟水含量远高于国外产单位产品虚拟水含量。总体来说,木质林产品属于水密集型产品,远高于农作物最终产品虚拟水含量。本著作是首次采用“生产树法”、从生产者角度对木质林产品单位虚拟水含量进行测算。

在主要木质林产品单位虚拟水含量值的基础上,本著作结合 2000~2010 年中国主要木质林产品的国际贸易量,计算了木质林产品国际贸易中的虚拟水贸易量,并从贸易规模、贸易结构和贸易平衡三个方面对中国木质林产品虚拟水贸易进行分析,确定了木质林产品虚拟水贸易在中国虚拟水贸易中的地位和对中国水资源利用的影响。并根据比较优势理论和虚拟水理论,结合世界及中国水资源状况,提出了中国木质林产品虚拟水战略:出口高附加值的低耗水型林产品,进口水密集型的林产品,以达到缓减中国水资源短缺、提高水资源利用效率的目的。本著作是首次研究中国木质林产品虚拟水贸易,并提出木质林产品虚拟水战略。

限于研究数据缺乏,研究问题复杂,本著作在森林虚拟水、木质林产品单位虚拟水含量测算中,采用替代、估计等方法,因此,存在一定的误差,仅供后来研究者参考。

著 者

2011 年 10 月 30 日

# Preface

Water resources have been becoming one of the important strategic factors affecting world development. In 1993, Tony Allan, a professor in London University, put forward and expanded the virtual water theory. The virtual water theory provides new ideas and new ways to settle global water balance, to improve water use efficiency, and to ease water shortages. So it has attracted many scholars and experts wide attention in related fields. China is one of the poorest countries in the world from per capita water resources. So, it is important for solving China's water resources problems and improving the development of national economy to study virtual water trade theory and implementing virtual water strategy. The researches on the virtual water of agricultural products have been improved more, and the quantization of agricultural products virtual water content has a more complete model. However, forest products, as a water-intensive product with a huge amount of international trade, have few studies on virtual water quantization and virtual water trade.

Woody forest products come from forests, the virtual water study of woody forest products is based on the study of forest virtual water. Based on the study on the relationship between forests and water, this study defines the concept of the forest virtual water. It refers to the amount of water consumed in the production of forest, it is a cumulative water consumption. Through the composition analysis of forest virtual water, this study thinks that the forest virtual water refers to the amount of water consumed by the forest evapotranspiration during the forest growing, consisted from water consumption of soil evaporation, canopy evaporation and forest transpiration. This study summarized the internal and external factors impacting forest virtual water, thinks that the climatic conditions, geographical conditions, forest itself conditions are the three aspects of affecting forest virtual water, each of which conditions include many factors and they are intertwined and influence each other interactions. Limited to lack of data, based on analyzing and summarizing the relationship between forest transpiration and forest evapotranspiration, and the characteristics of water consumption in forest transpiration of different species, this study uses the alternative method, to calculate the amount water consumption of forest evapotranspiration with forest transpiration, to calculate the forest virtual water of coniferous forest and broad-leaved forest with representative tree species of them by mathematical modeling method. This study is the first to propose the definition and measure theory of forest virtual water, and put the calculation of forest virtual water into practice.

In this study, main woody forest products, including logs (including softwood and



hardwood timber logs), lumber (including softwood lumber and hardwood lumber), wood-based panels (including veneer, plywood, particleboard and fiberboard) and pulp, paper and cardboard with wood as raw material, are estimated by production tree method. The virtual water of woody forest products are composed of the virtual water contained by raw materials (wood and other raw materials) and the water consumption in forest products processing. The virtual water contained by wood as raw materials occupies most of the virtual water. Water consumption in forest products processing include actual water consumption in forest products processing and the virtual water of energy consumption. The results showed: the virtual water content of wood pulp per unit of product is the highest, and in wood-based panels, the virtual water content of plywood per unit of product is highest. Overall, virtual water content of forest products with broadleaf wood as raw material is higher than ones with coniferous wood as raw material. Overall, woody forest products are water-intensive products, much higher than the crop virtual water content of the final product. This study is the first to measure the virtual water content of wood forest products per unit of product from the point of view of producer by production tree method.

Based on the virtual water content of the main woody forest products per unit of product, with combining China's international trade of main timber products from 2000 to 2010, this study calculates the virtual water trade in the international trade of main timber products, and analyzes it from three aspects as trade size, trade structure and trade balance, to know the position which the virtual water trade of China's woody forest products take up in China's virtual water trade and the impact on China's water use. And in accordance with the theory of comparative advantage and virtual water theory, combined with the world and China's water resources, this study proposes China's virtual water strategy of woody forest products. High value-added and low water-based forest products should be exported, water-intensive forest products should be imported. These will alleviate the shortage of water resources, to improve water use efficiency. This study is the first study of virtual water trade and the virtual water strategy in woody forest products in China.

Limited to the lack of research data and the complex issues, this study uses alternative and estimation methods to measure the virtual water content of woody forest products. So there is a certain error, the results only are the referenced by later researchers.

# 目 录

出版说明

序 言

前 言

第1章 绪 论 .....	(1)
1.1 研究背景和研究意义 .....	(1)
1.2 国内外研究进展 .....	(5)
1.3 研究范畴、研究内容、方法和技术路线 .....	(17)
1.4 小 结 .....	(20)
第2章 虚拟水理论和虚拟水的计算方法 .....	(23)
2.1 虚拟水研究的沿革 .....	(23)
2.2 虚拟水概念和内涵 .....	(24)
2.3 虚拟水的计算方法 .....	(29)
2.4 小 结 .....	(40)
第3章 森林虚拟水理论、测度方法与测算研究 .....	(41)
3.1 森林与水的研究综述 .....	(41)
3.2 森林虚拟水的讨论 .....	(49)
3.3 森林虚拟水测度方法 .....	(58)
3.4 中国森林虚拟水的初步测算 .....	(64)
3.5 小 结 .....	(76)
第4章 中国主要木质林产品单位虚拟水含量测算研究 .....	(77)
4.1 单位原木虚拟水含量的测算 .....	(77)
4.2 单位锯材虚拟水含量的测算 .....	(81)
4.3 单位人造板虚拟水含量的测算 .....	(84)
4.4 单位纸浆和纸虚拟水含量的测算 .....	(96)
4.5 主要木质林产品单位产品虚拟水含量汇总与分析 .....	(116)
4.6 小 结 .....	(118)
第5章 中国主要木质林产品国际贸易中虚拟水贸易研究 .....	(120)
5.1 虚拟水进出口贸易量计算方法 .....	(121)

---

5.2	中国主要木质林产品进出口贸易分析 .....	(122)
5.3	中国主要木质林产品虚拟水进出口贸易分析 .....	(130)
5.4	小 结 .....	(145)
第6章	研究结论与建议 .....	(146)
6.1	研究结论 .....	(146)
6.2	研究建议 .....	(149)
6.3	小 结 .....	(156)
参考文献	.....	(157)

# Contents

Publication Introduction

Foreword

Preface

<b>Chapter 1 Introduction</b>	(1)
1.1 Background and significance	(1)
1.2 Domestic and international research	(5)
1.3 Scope of the study、research contents、methods and technology roadmap	(17)
1.4 Summary	(20)
<b>Chapter 2 Virtual water theory and the calculation methods</b>	(23)
2.1 History of virtual water study	(23)
2.2 Concept and content of virtual water	(24)
2.3 Calculation methods of virtual water	(29)
2.4 Summary	(40)
<b>Chapter 3 Forest virtual water theory, measurement methods and         calculation</b>	(41)
3.1 Review of forest and water research	(41)
3.2 Discussion about forest virtual water	(49)
3.3 Measurement methods of forest virtual water	(58)
3.4 Preliminary estimates of China's forest virtual water	(64)
3.5 Summary	(76)
<b>Chapter 4 Measurement of virtual water content of China's main woody         forest products</b>	(77)
4.1 Measurement of log's virtual water content	(77)
4.2 Measurement of sawn timber's virtual water content	(81)
4.3 Measurement of wood - based panel's virtual water content	(84)
4.4 Measurement of pulp and paper's virtual water content	(96)
4.5 Summary and analysis of virtual water content of China's main woody	



---

forest products .....	(116)
4.6 Summary .....	(118)
<b>Chapter 5 Virtual water trade of China's main woody forest products in international trade .....</b>	<b>(120)</b>
5.1 Calculation methods of virtual water import and export trade .....	(121)
5.2 Analysis of China's main woody forest products import and export trade .....	(122)
5.3 Analysis of virtual water import and export trade of China's main woody forest products .....	(130)
5.4 Summary .....	(145)
<b>Chapter 6 Conclusions and proposals .....</b>	<b>(146)</b>
6.1 Research Conclusion .....	(146)
6.2 research proposals .....	(149)
6.3 Summary .....	(156)
<b>Reference .....</b>	<b>(157)</b>