Foreword —

The development of Numerical Ecology in China, an example of international scientific cooperation

Foreword to Numerical ecology with R, 2nd Chinese edition *by D. Borcard, F. Gillet & P. Legendre (translation to Chinese: J. Lai, Institute of Botany, Chinese Academy of Sciences). Higher Education Press Beijing. Publication date: 9 May 2020.*

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Books do not grow on peach trees. This book is the result of a fairly long chain of events and the collaborative work of many dedicated people.

■ *Numerical ecology*

Numerical ecology is the field of quantitative ecology devoted to the numerical analysis of data, which are mostly multivariate, with emphasis on community composition data, aimed at understanding the processes that generate and maintain biodiversity in ecosystems. Many of the methods used in numerical ecology were developed by ecologists, specialists of classification methods, geneticists and other researchers who were facing questions about multivariate data in their fields of study.

The unofficial foundation of *Numerical Ecology* as a sub-discipline of ecology took place during a conference that was held in southern France in May 1975, where a dozen or so ecologists, mostly interested in marine ecosystems, sat during three days in a classroom in the *Station marine de Villefranche-sur-Mer* (Université Paris 6, France), a few meters away from the Mediterranean shore, to discuss a new trend in the ecological literature: the statistical analysis of multivariate ecological data. The meeting was called "*Séminaire de mathématiques appliquées à l'océanographie biologique*" [Seminar on Mathematics Applied to Biological Oceanography] and had a marine ecology orientation. The development of this field from the years 1960's to the present has been recounted in an encyclopaedia article by Legendre (2019). The field has developed thanks to a large number of dedicated scientists working in universities and research institutes throughout the world, who developed a broad palette of methods of analysis to answer ecological questions and test ecological hypotheses. Some of their most important methodological publications are listed in that paper (Legendre 2019).

■ *Forest dynamics plots*

Forest dynamics plots are now found around the world. In 2019, 67 forest plots located in 27 countries are members of the *Forest Global Earth Observatory* (ForestGEO, https://forestgeo.si.edu/), coordinated by the *Center for Tropical Forest Science* (CTFS). The first plot of the ForestGEO-CTFS network was the Barro Colorado Forest Dynamics plot established in Panama in 1981 by Robin B. Foster and Stephen P. Hubbell (Hubbell and Foster 1983). The objective of the network is to advance our understanding of natural forests by repeatedly surveying forest plots that have been set aside for research around the world, in order to

understand how ecological diversity is generated and maintained in forests in the face of a changing world.

The ForestGEO Web page lists 14 forest plots in China. Most of them are members of the *Chinese Forest Biodiversity Monitoring Network*. How did these plots develop and how was this network created? Here is a summary of how it happened, based upon information provided to me by some of the key people who were involved in the development of the Chinese plot network.

In the summer of year 2000, Stephen P. Hubbell travelled to Changbaishan with his wife, the evolutionary biologist Patricia A. Gowaty, and plant ecologist I-Fang Sun, now Professor at the Dong Hwa University in Hualien. Hubbell had long been interested in Changbaishan, which is one the most diverse temperate forests in the world. They also travelled to Beijing and visited the Institute of Botany of the Chinese Academy of Science to promote the idea of establishing a forest plot in China following the methodology implemented in the ForestGEO-CTFS network sponsored by the Smithsonian Tropical Research Institute. Keping Ma was then deputy director of the Institute of Botany.

In 2002, Fangliang He (University of Alberta, Canada) met a delegation of officials of the Chinese Academy of Sciences, led by Yivu Chen, Deputy Director General of the Academy, to discuss the establishment of a network of Chinese forest plots affiliated to the CTFS network. At the suggestion of Yivu Chen, Fangliang He went to Beijing in the fall of 2003 to discuss his project of establishing a latitudinal network of plots in China with Keping Ma, the then Deputy Director of the Institute of Botany.

At the invitation of Keping Ma, Fangliang He, I-Fang Sun and Stuart Davis (from CTFS) held a two-day workshop in the Institute of Botany in February 2004, with some 25 participants. Among these were the principal investigators from five Chinese research organizations who were interested in long-term plot-based research – Shenyang Institute of Applied Ecology: Zhanqing Hao, Changbaishan plot; East China Normal University: Xihua Wang, Tiantongshan plot; Zhejiang University: Mingjian Yu, Gutianshan plot; South China Botanic Garden: Wanhui Ye, Dinghushan plot; Xishuangbanna Botanical Garden: Min Cao, Xishuangbanna plot. During that workshop, definite plans were made to launch the network of Chinese forest plots.

I-Fang Sun went to Changbaishan in June 2004 to help establish the plot and train a group of young scientist from several potential sites in the CTFS forest plot methodology. Changbaishan (25 ha) was the first Chinese plots to be censused in 2004. It was followed by Gutianshan (24 ha) and Dinghushan (20 ha) in 2005. The network has since kept growing, with new plots being added every year. Stem-mapping plots have become a major natural infrastructure in ecological research in China and they play a crucial role in the global ForestGEO-CTFS network.

National or regional forest plot networks have been established in different countries around the world to advance our understanding of natural forests or to provide scientific data for forest management by governments and the forestry industry. In China, besides the *Chinese Forest Biodiversity Monitoring Network*, another national network of forest plots was developed by Beijing Forestry University to advance our understanding of forest ecology. The *Beijing Forest Ecosystems Observation Network* was established in 2005. It started with three plots in the Changbaishan forest region and it currently comprises 19 plots located in 10 provinces, including autonomous regions and municipalities (Zhao et al. 2014).

■ *How should forest plot data be analysed*

How to analyse forest plot data was the subject of a four-week course organized in July 2006 by Keping Ma and Fangliang He at the Zhuozhou Training Center, to the southwest of Beijing, in an effort to train students and researchers to use the R statistical software for analysing stem-mapping plot data.

The participants in the workshop included graduate students and postdoc researchers who had worked in the surveys of the Changbaishan and Gutianshan forest plots. This was the very first time that R was introduced to the community of Chinese ecologists. Three guest speakers were invited to lecture during one week each. They had agreed to offer exercises in R to the workshop participants, establishing R as the common computer language for analysis of forest plot data in China in the future. The workshop started with an introduction to R by Haibao Ren during the first week. Haibao Ren and Xiangcheng Mi had learned R in 2005 during a 4-month internship in the lab of Prof. Fangliang He at the University of Alberta in Canada. They were the first Chinese ecologists to use R.

I occupied the podium during the second week (*Advanced spatial ecology*), followed by Fangliang He in the third week (*Biodiversity analysis*) and Richard Condit during the fourth week (*Analyzing and mapping data with R*). The workshop continued in the field with a visit to the recently censused Gutianshan forest plot. During the workshop, Keping Ma had asked me to lead a first analysis of the Gutianshan plot census data and write a paper with the other main investigators. This work produced a first scientific paper about the Gutianshan plot published in the journal *Ecology* (Legendre et al. 2009).

In 2009, Prof. Keping Ma asked me to give a new course of numerical ecology and spatial analysis to the graduate students of the Institute of Botany and from other universities and institutes associated with the Chinese forest plots. The course, sponsored by the *Biodiversity Committee*, *Chinese Academy of Science* and entitled *Recent advances in spatial ecology: theory and practice*, took place from 1st to 6th of October at the Institute of Botany in Beijing; that week coincided with the 60th anniversary of the foundation of the *People's Republic of China* in 1949. Forty participants followed the course, including Jiangshan Lai who later translated the present book to Chinese.

■ *Numerical ecology with R*

Numerical ecology with R (abbreviated NEwR) is the name of a book published in 2011 by Daniel Borcard and his co-authors, François Gillet and myself. The objective of that book was to explain to ecologists, graduate students in ecology and teachers of numerical ecology methods how to analyse ecological data using a selection of the most popular methods of multivariate quantitative analysis, using the R language. Extensive R packages had been developed for community ecology analysis since R had been released on *The Comprehensive R Archive Network* (CRAN) site on 29 February 2000: *vegan* had appeared on CRAN in 2001, *ade4* in 2002, *FactoMineR* in 2006; *adespatial* appeared later, in 2016.The time was ripe to present in an organized manner this wealth of functions for the analysis of ecological data, which are multivariate for the most part. We had the hope that the book would be useful not only to practicing ecologists and graduate students in ecology, but also to teachers of numerical ecology methods.

After publication of the NEwR book in 2011 and of the 3rd English edition of the *Numerical Ecology* book (Legendre and Legendre 2012), Jiangshan Lai, who was then Research Assistant

Professor, State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, took it on himself to translate the NEwR book to Chinese. The first Chinese edition was published in May 2014 by Higher Education Press, Beijing. Jiangshan Lai then came to our lab at Université de Montréal (Canada) as a guest researcher during a year in 2014-2015 to learn more about the methods of numerical ecology. Following that, he was repeatedly invited in labs and universities throughout China (and also in Nepal) to talk about numerical ecology and the R book and he was offered a Faculty position at the new University of the Chinese Academy of Science in Beijing.

When the second English edition of the NEwR book was published in 2018, Daniel Borcard sent the manuscript files of the new edition to Jiangshan Lai who had offered to produce a second edition of the book in Chinese. Given the sales success of the first Chinese edition, Higher Education Press offered him a contract to translate the second edition of the NEwR book to Chinese, and Dr. Lai started to work on the translation. Recently, he wrote to Daniel Borcard and me that the translation should be completed early in the year 2019, and he asked me to write a Foreword for the new Chinese edition. This invitation offered me the opportunity to put together, from my notes and consultation with some key players in the events, this brief history of the development of *Numerical Ecology* in China, a story that started in 2006. This new book should be useful to all Chinese ecologists, including all the researchers who work in the various forest study networks of the country.

How the development of the *Chinese Forest Biodiversity Monitoring Network* started and led, many years later, to the publication of the present R book is a nice example of international cooperation among scientists. I am very happy to have played a role in this adventure.

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前言 -
中国数字生态学的发展，国际科学合作的一个例子

像你手中的那些书不会在桃树上生长。本书是一系列相当长的事件和许多敬业者的协作工作的结果。

■ 数值生态学

数值生态学是定量生态学领域，致力于数据的数值分析，主要是多变量，重点是社区组成数据，旨在了解生成和维护生态系统中生物多样性的过程。数值生态学中使用的许多方法都是由生态学家，分类方法专家，遗传学家和其他研究人员开发的，他们在研究领域面临着多变量数据的问题。

1975 年 5 月在法国南部举行的一次会议期间，数字生态学作为生态学学科的非官方基础发生在那里，十几位生态学家，主要是对海洋生态系统感兴趣，他们在三天的教室里坐在 Station de Villefranche-sur-Mer（Université Paris 6，France），距地中海岸仅数米之遥，探讨生态文学的新趋势：多元生态数据的统计分析。这次会议被称为“应用于生物海洋学的数学研讨会”，并以海洋生态为导向。这一领域从 1960 年代到现在的发展在 Legendre（2019）的百科全书文章中有所描述。该领域得益于在世界各地的大学和研究机构工作的大量专业科学家，他们开发了广泛的分析方法，以回答生态问题和测试生态假设。他们的一些最重要的方法论出版物列在该论文中（Legendre 2019）。

■ 森林动态图

现在，世界各地都发现了森林动态地块。2019 年，27 个国家的 67 个森林地块是森林全球地球观测站（ForestGEO，https：//forestgeo.si.edu/）的成员，由热带森林科学中心（CTFS）协调。 ForestGEO-CTFS 网络的第一个图是 1981 年由 Robin B. Foster 和 Stephen P. Hubbell（Hubbell 和 Foster 1983）在巴拿马建立的 Barro Colorado Forest Dynamics 图。该网络的目标是通过反复调查为世界各地的研究预留的森林地块来提高我们对天然林的认识，以便了解在不断变化的世界中如何在森林中生成和维持生态多样性。

ForestGEO 网页列出了中国的 14 个森林地块。其中大多数是中国森林生物多样性监测网络的成员。这些情节是如何发展的？这个网络是如何形成的？根据参与中国情节网络发展的一些关键人物向我提供的信息，以下是对其发生情况的总结。

2000 年夏天，Stephen P. Hubbell 和他的妻子，进化生物学家 Patricia A. Gowaty 以及植物生态学家 I-Fang Sun（现为花莲东华大学教授）一起前往长白山。 Hubbell 长期以来对长白山感兴趣，长白山是世界上最多样化的温带森林之一。他们还前往北京，参观了中国科学院植物研究所，根据史密森热带研究所赞助的 ForestGEO-CTFS 网络实施的方法，推广了在中国建立森林地块的想法。 Keping Ma 当时是植物学研究所的副主任。

2002 年，何方良（加拿大阿尔伯塔大学）会见了由中国科学院副院长 Yivu Chen 领导

的中国科学院官员代表团，讨论建立中国森林土地网络的问题。 CTFS 网络。在陈一夫的建议下，何方良于 2003 年秋季前往北京，与植物研究所当时的副主任马炳文讨论了他在中国建立中国纬度网络的项目。

应 Keping Ma 的邀请，何方良，I-Fang Sun 和 Stuart Davis（来自 CTFS）于 2004 年 2 月在植物研究所举办了为期两天的研讨会，约有 25 人参加。其中包括对长期基于地块的研究感兴趣的五个中国研究机构的主要研究人员 - 沉阳应用生态研究所：张湛卿，长白山地块;华东师范大学：王西华，天台山情节;浙江大学：明建宇，古田山情节;华南植物园：万辉叶，鼎湖山地块;西双版纳植物园：西曹板南的曹敏。在那次研讨会期间，制定了明确的计划，以启动中国森林地块网络。

I-Fang Sun 于 2004 年 6 月前往长白山，帮助建立该地块，并在 CTFS 森林地块方法中培养了一批来自几个潜在地点的年轻科学家。长白山（25 公顷）是 2004 年首批进行人口普查的中国地块。2005 年，古天山（24 公顷）和鼎湖山（20 公顷）紧随其后。该网络不断发展，每年新增土地。茎秆图已成为中国生态研究的主要自然基础设施，并在全球 ForestGEO-CTFS 网络中发挥着至关重要的作用。

在世界各国建立了国家或区域森林地块网络，以促进我们对天然林的了解，或为政府和林业部门的森林管理提供科学数据。在中国，除中国森林生物多样性监测网外，北京林业大学还开发了另一个全国森林网络，以促进我们对森林生态的认识。北京森林生态系统观测网络成立于 2005 年。它始于长白山林区的三个地块，目前包括 19 个地块，分布在 10 个省，包括自治区和直辖市（Zhao 等，2014）。

■ 如何分析森林地块数据

如何分析森林地块数据是 2006 年 7 月由 Keping Ma 和 Fangliang He 在北京西南 Zhu 州培训中心组织的为期四周的课程，旨在培养学生和研究人员使用 R 统计用于分析茎映射图数据的软件。

研讨会的参与者包括曾在长白山和古田山森林调查中工作的研究生和博士后研究人员。这是 R 首次被引入中国生态学家社区。三位嘉宾演讲者分别在一周内受邀演讲。他们同意向研讨会参与者提供 R 练习，将 R 作为未来中国森林地块数据分析的通用计算机语言。研讨会在第一周由海宝仁介绍了 R。 2005 年，海宝仁和龚成成在加拿大阿尔伯塔大学实验室实习 4 个月，学习了 R.他们是第一批使用 R 的中国生态学家。

我在第二周（高级空间生态学）中占据了领奖台，其次是第三周的方良和（生物多样性分析）和第四周的 Richard Condit（用 R 分析和绘制数据）。研讨会继续在现场参观最近审查的古田山森林地块。在研讨会期间，Keping Ma 邀请我首先分析古田山地块的人口普查数据，并与其他主要调查人员一起撰写论文。这项工作产生了第一篇关于古田山地块的科学论文，发表在生态学杂志上（Legendre et al. 2009）。

2009 年，马克平教授邀请我为植物研究所和其他与中国森林相关的大学和研究所的研究生提供数值生态学和空间分析的新课程。该课程由中国科学院生物多样性委员会主办，题为“空间生态学的最新进展：理论与实践”，于 10 月 1 日至 6 日在北京植物研究所举办; 那个星期恰逢 1949 年中华民国成立 60 周年。有 40 名学员参加了这个课程，其中包括赖山山，后来将这本书翻译成中文。

■ R 的数值生态学

数字生态学与 R（缩写为 NEwR）是 Daniel Borcard 及其合着者 FrançoisGillet 和我自己在 2011 年出版的一本书的名称。该书的目的是向生态学家，生态学研究生和数值生态学教师解释如何使用 R 语言选择最常用的多变量定量分析方法来分析生态数据。自从 R 于 2000 年 2 月 29 日在综合档案网络（CRAN）网站上发布以来，已经开发了大量的 R 包用于社区生态学分析：2001 年，素食主义者出现在 CRAN，2002 年出现了 ade4，2006 年出现了 FactoMineR; adespatial 出现在 2016 年晚些时候。时机成熟，以有组织的方式呈现了丰富的生态数据分析功能，这些功能在很大程度上是多变量的。我们希望这本书不仅对生态学家和生态学研究生有用，而且对数学生态学方法的教师也有用。

2011 年出版了 NEwR 书籍和“数字生态学”第 3 版英文版（Legendre and Legendre 2012）后，赖江山，当时中国植物研究所植被与环境变化国家重点实验室研究助理教授科学院自己把 NEwR 书翻译成中文。第一部中文版于 2014 年 5 月由北京高等教育出版社出版。赖江山随后于 2014 - 2015 年作为客座研究员来到加拿大蒙特利尔大学实验室，了解更多有关数值生态学方法的知识。之后，他多次受邀在中国（以及尼泊尔）的实验室和大学里谈论数字生态学和 R 书，并在北京中国科学院新大学获得了教师职位。

当 NEwR 书的第二版英文版于 2018 年出版时，Daniel Borcard 将新版的手稿文件发送给了江山莱，后者曾提出用中文出版第二版。鉴于第一版中文版的销售成功，高等教育出版社向他提供了将第二版 NEwR 书翻译成中文的合同，赖博士开始从事翻译工作。最近，他写信给 Daniel Borcard 和我，翻译应该在 2019 年初完成，他让我为新的中文版写了一篇前言。这个邀请让我有机会从我的笔记和与活动中的一些主要参与者的磋商中汇总了这个关于中国数字生态学发展的简史，这个故事始于 2006 年。这本新书应该对所有人都有用。中国生态学家，包括在该国各种森林研究网络中工作的所有研究人员。

多年以后，中国森林生物多样性监测网络的发展如何开始并引领出版现在的 R 书，是科学家之间国际合作的一个很好的例子。我很高兴能在这次冒险中扮演一个角色。

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