



中国植物分布模拟研究现状

刘晓彤¹ 袁 泉¹ 倪 健^{1,2*}

¹浙江师范大学化学与生命科学学院, 浙江金华 321004; ²浙江金华山亚热带森林生态系统野外科学观测研究站, 浙江金华 321004

摘 要 在过去的20年里, 物种分布模型已广泛应用于动植物地理分布的模拟研究。该文以植物物种分布模拟为例, 利用中国知网、维普网以及Web of Science文献数据库的检索与统计, 分析了2000–2018年间, 中国研究人员利用各种物种分布模型对植物物种分布模拟研究的发文量、模拟模型、物种类型、数据来源、研究目的等信息。最终共收集到366篇有效文献, 分析表明2011年以来中国的物种分布模型应用发展迅速, 且以最近5年最为迅猛, 在生态学、中草药业、农业和林业等行业部门应用广泛。在使用的33种模型中, 应用最广的为最大熵模型(MaxEnt)。有一半研究的环境数据仅包含气候数据, 另一半研究不仅包含气候数据还包括地形与土壤等数据; 环境及物种数据的来源多样, 国际及本土数据库均得到使用。模拟涉及有明确清单的562个植物种, 既有木本植物(52.7%), 也有草本植物(41.8%), 其中中草药、果树、园林植物、农作物等占比较高。研究目的主要集中在过去、现在和未来气候变化对植物种分布的影响及预测, 以及物种分布评估与生物多样性评价(包括入侵植物风险评估)两大方面。预测物种潜在分布范围与气候变化影响等基础研究, 与模拟物种适生区与推广种植等应用研究并重, 物种分布模型在生态学、农业、林业和中草药业等多学科、多行业开展多种应用, 多物种、多模型和多来源数据共同参与模拟与比较, 开发新的机理性物种分布模型, 拓展新的物种分布模拟应用领域, 是今后研究的重点发展方向。

关键词 物种分布模型; 气候变化; 生物多样性保护; 潜在分布区; 最大熵模型

刘晓彤, 袁泉, 倪健 (2019). 中国植物分布模拟研究现状. 植物生态学报, 43, 273–283. DOI: 10.17521/cjpe.2018.0237

Research advances in modelling plant species distribution in China

LIU Xiao-Tong¹, YUAN Quan¹, and NI Jian^{1,2*}

¹College of Chemistry and Life Sciences, Zhejiang Normal University, Jinhua, Zhejiang 321004, China; and ²Jinhua Mountain Observation and Research Station for Subtropical Forest Ecosystems, Jinhua, Zhejiang 321004, China

Abstract

Species distribution models (SDMs) have been extensively used in simulations of geographical distribution of animal and plant species during the past 20 years. Taking the simulation of plant species distribution as an example, we used both the digitized and library databases including the China National Knowledge Infrastructure (CNKI), the VIP Chinese Journal Database (VIP) and the Web of Science (WoS) to compile available literatures published from 2000 to 2018. The number of publications, SDMs used, target plant species, data sources, and the purpose of studies about using various SDMs to simulate plant species distribution in China was statistically investigated. In total 366 publications were collected. Further analysis and synthesis showed that the application of SDMs in simulating Chinese plant species distribution has developed rapidly since 2011, especially during the past five years. SDMs have been used in studies of ecology, Chinese traditional medicine, agriculture, and forestry. The Maximum Entropy Model (MaxEnt) is the most widely used model among 33 commonly used SDMs. A half of the studies use climate data only, and another half of the studies use both climate, soil and topography data. The source of both environmental data and plant distribution data are diverse, derived from international and domestic databases. In these studies, researchers have simulated the distribution of 562 plant species, in which 52.7% are woody species and 41.8% are herbaceous species, including a large number of Chinese medicinal plants, fruit trees, garden plants, and crops. Studies aim mainly on two aspects, i.e. the impact of climate change on plant species distribution and their predicted pattern in the past, present, and future climate scenarios, and the assessment of the potential distribution of plant species and biodiversity trends (including the risk of invasive species). In future studies, more attention should be paid to both the basic science on the modelling of potential

收稿日期Received: 2018-09-25 接受日期Accepted: 2019-03-20

基金项目: 国家自然科学基金(41471049). Supported by the National Natural Science Foundation of China (41471049).

* 通信作者Corresponding author (nijian@zjnu.edu.cn)

distribution of plant species and the impact from climate change, and the applied science on the prediction of suitable distribution area of plant species in order to popularize their plantation. More applications of SDMs in multiple disciplines and in multiple industries such as ecology, forestry, crop science and Chinese traditional medicine should be further developed. Joint simulations and inter-comparisons using multiple plant species, more SDMs and multiple data sources of environmental data, as well as the development of new and mechanism SDMs are encouraged. The extension of model applications in new research fields is also needed.

Key words species distribution models; climate change; biodiversity conservation; potential distribution area; Maximum Entropy Model

Liu XT, Yuan Q, Ni J (2019). Research advances in modelling plant species distribution in China. *Chinese Journal of Plant Ecology*, 43, 273–283. DOI: 10.17521/cjpe.2018.0237

物种分布模型是基于生态位概念, 利用观测到的物种分布数据及环境变量来推断物种的生态需求, 并绘制其潜在分布的统计性或机理性模型(王娟和倪健, 2006; Elith & Leathwick, 2009)。其基本原理是利用已有的物种分布数据及其对应的环境参数, 关联性构建二者的相关模型, 以确定物种的实际分布区和判断物种的潜在分布区(Araújo & Peterson, 2012; 朱耿平等, 2013)。近20年来, 物种分布模型在生物多样性评估、自然保护区设计、物种迁地保护生境的筛选、环境风险评估、入侵物种管理、群落和生态系统分布模拟、全球环境变化对物种和生态系统影响的预测等方面得到了广泛的应用(Guisan & Thuiller, 2005; Elith & Leathwick, 2009; 李国庆, 2011; 许仲林等, 2015)。

基于计算机的物种分布模型最早发展于20世纪70年代中期, 用于农作物的潜在空间分布区预测(Nix *et al.*, 1977), 但受到当时物种与环境有效数据的限制, 并未得到广泛的应用。到20世纪80年代, 随着计算机技术和统计学的发展, 尤其是90年代以来, 地理信息系统技术的快速发展, 以及数字高程、气候与环境数据、遥感数据等资源的公开获取, 极大地推动了物种分布模型的发展。自20世纪90年代初期BIOCLIM模型(Busby, 1991)的开发和应用之后的近30年里, 生态学家发展了多种物种分布模型, 如HABITAT模型、DOMAIN模型、生态位因子分析模型(ENFA)、马氏距离(MD)、边界函数方法(BF)、最大熵模型(MaxEnt)、广义线性模型(GLM)、广义加法模型(GAM)、分类与回归树模型(CART)、多元适应性回归样条(MARS)、基于规则集的遗传算法(GARP)和人工神经网络(ANN)等, 并广泛应用于多学科方向的研究中(许仲林等, 2015)。

中国学者利用国际上成熟的模型开展了大量的植物物种潜在分布的模拟工作, 尤其是进入21世纪

后, 对目标物种的潜在分布区预测(蒋霞和倪健, 2005; 高蓓等, 2015; 毛俐慧等, 2017)及物种分布对气候变化的响应(刘少军等, 2015; 贾翔等, 2017)等方面开展了诸多工作。其中, 相关学者发表了多篇物种分布模型的综述文章(王娟和倪健, 2006; 陈新美等, 2012; 李国庆等, 2013; 许仲林等, 2015), 但大部分侧重模型本身的方法、原理、验证等, 尚未对国内物种分布模型的应用进展及其存在的缺陷进行总结。

因此, 到目前为止, 我们尚不清楚: 国内学者利用物种分布模型做了哪些研究; 哪些物种分布模型得到了我国学者的广泛应用; 模拟了哪些植物物种, 其主要研究目的是什么; 国内从事物种分布模拟研究的单位和学者集中在哪些地区和机构。由此, 本文旨在对中国学者应用物种分布模型模拟植物物种分布的现状进行总结, 梳理目前存在的问题及可能的解决方案, 指出我国物种分布模拟的未来努力方向。

1 文献收集与整理

对2000年1月至2018年1月期间发表的有关物种分布模型的文献进行搜集。搜集方式有两种, 一是基于文献数据库进行检索, 其中基于中国知网和维普网数据库收集中文文献, 包括学位论文库, 以物种分布模型、最大熵、遗传算法、BIOCLIM、广义相加、广义线性、分类回归树、人工神经网络等为关键词; 英文文献采用Web of Science数据库, 以China、species distribution、MaxEnt、GARP、BIOCLIM、GAM、GLM、CART、ANN等为关键词, 进行交叉检索。二是通过期刊进行搜集, 对较多发表物种分布模型文章的期刊逐卷逐期浏览检索, 主要包括《植物生态学报》《生态学报》《应用生态学报》《生态学杂志》《生物多样性》《林业科学》等。

对检索和收集到的文献进行筛选,剔除与植物物种分布研究相关、但未采用物种分布模型模拟的论文,如样地尺度的物种共存研究,或大尺度的物种分布机理研究等,最终得到利用物种分布模型模拟我国植物物种分布的有效文献366篇。

从文献计量学的角度,定量地统计文献所记录的信息,提取中国植物物种分布模型应用相关文章的年度发文量、模拟物种、模拟模型、模拟目的等相关数据,并进行统计分析。

2 物种分布模型及其应用现状

2.1 文献分析

通过检索共收集366篇文献(附录I),其中中文文献260篇,占文献总数的71.0%,英文文献106篇,占29.0%。从文献类型来看,学术期刊论文326篇,占89.1%;学位论文37篇,占10.1%;会议论文3篇,占0.8%。2005年以前我国物种分布模拟方面的研究较少,故本文以2005年为时间节点,对物种分布模型的应用文献数量进行分析。统计每年的发文量(图1)可知,我国有关植物物种分布模型应用的文章数量呈不断增长的趋势。尤其从2011年开始,发文量迅速增加,在仅占总统计时间一半的时间段,发表文章326篇,占总文章数的89.1%,表明近年来物种分布模型在我国得到越来越多的关注与应用,且以发表中文研究论文为主。

326篇学术期刊论文主要分布在151种期刊。发文量排名前10的16种期刊所载文献数达139篇(表1),即10.6%的期刊发表了42.9%的物种分布模拟研究论文。第一作者和通讯作者工作单位是论文的主要

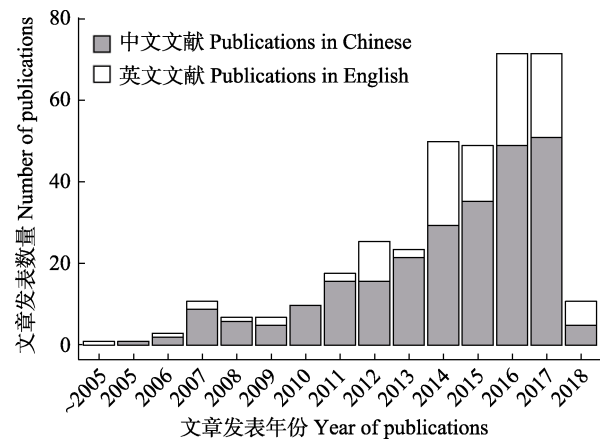


图1 中国植物物种分布模型应用文章的发表数量。
Fig. 1 Number of papers about the distribution of plant species simulated by species distribution models in China.

表1 发表植物物种分布模型研究的重要期刊(2000-01-2018-01)
Table 1 Top journals publishing articles of plant distribution modelling from China (from 2001-01 to 2018-01)

排名 Rank	期刊 Journal	载文量(篇) Number of papers published
1	中国中药杂志 <i>China Journal of Chinese Materia Medica</i>	23
2	植物生态学报 <i>Chinese Journal of Plant Ecology</i>	15
3	生态学报 <i>Acta Ecologica Sinica</i>	14
4	应用生态学报 <i>Chinese Journal of Applied Ecology</i>	13
5	生态学杂志 <i>Chinese Journal of Ecology</i>	12
6	<i>PLOS ONE</i>	11
7	林业科学 <i>Scientia Silvae Sinica</i>	7
8	中药材 <i>Journal of Chinese Medicinal Materials</i>	6
	生物多样性 <i>Biodiversity Science</i>	6
9	生物安全学报 <i>Journal of Biosafety</i>	5
	广东农业科学 <i>Guangdong Agricultural Sciences</i>	5
	草业学报 <i>Acta Prataculturae Sinica</i>	5
	<i>Scientific Reports</i>	5
10	广西植物 <i>Guihaia</i>	4
	<i>Ecology and Evolution</i>	4
	<i>Polish Journal of Ecology</i>	4

研究机构,我国植物物种分布模拟相关文章(包括学术期刊论文、学位论文和会议论文)的发表单位共检索到117个,中国科学院的发文量最多,共63篇,占总发文量的17.5%,高于其他相关的研究机构,尤其以中国科学院植物研究所(23篇,占6.3%)居首。其他发文量较多的机构主要是高校,包括陕西师范大学(28篇,占7.7%)、南京林业大学(18篇,占4.9%)、北京林业大学(16篇,4.4%)等。以2010年为统计节点,2010年及以前共发表相关文章40篇,以中国科学院为第一研究单位的有17篇,占42.5%;2010年以后共326篇文章发表,中国科学院共发表46篇,占比12.6%。无论是研究早期还是近期,中国科学院的发文量均居榜首。但2010年以后各大学的发文量所占比重显著上升,显示出大专院校在物种分布模拟研究领域的迅猛发展。

2.2 模型统计

在收集到的366篇文献中,中国学者共使用了33种模型模拟植物物种分布,总计应用526次,其中有39篇论文利用多种模型进行分布模拟。在这33种模型(表2)中,应用最为广泛的当属MaxEnt,有80.1%的论文应用该模型进行了物种分布模拟。西南大学钟艮平(2008)在其硕士学位论文中较早应用

表2 模拟中国植物种分布的模型及其应用次数

Table 2 Statistics of publications modeling plant species in China using species distribution models

模型名称 Model	应用数量 Number of publications	模型名称 Model	应用数量 Number of publications
最大熵模型 Maximum Entropy Model (MaxEnt)	296	拟合神经网络 Fit Neural Networks (NNET)	3
基于规则集的遗传算法 Genetic Algorithm for Rule-set Prediction (GARP)	27	循环分区回归树 Recursive Partitioning and Regression Trees (RPART)	3
生物气候模型 BIOCLIM	26	Logistic回归模型 Logistic Regression (LR)	3
广义线性模型 Generalized Linear Model (GLM)	21	CLIMEX	2
广义相加模型 Generalized Additive Model (GAM)	21	作物生态需求 Crop Ecological Requirements (ECOCROP)	2
随机森林 Random Forest (RF)	19	农业生态区模型 Agriculture Ecological Zone Model (AEZ)	1
DOMAIN	13	决策树模型 Classification Tree Model (CT)	1
推进式回归树 Generalized Boosted Regression Models/Boosted Regression Tree (GBM/BRT)	13	生态位因子分析模型 Ecological Niche Factor Analysis (ENFA)	1
多元适应回归样条函数 Multivariate Adaptive Regression Splines (MARS)	12	GREEN	1
人工神经网络 Artificial Neural Network (ANN)	11	生境适生性模型 Habitat Suitability Model (HSM)	1
柔性判别分析 Flexibled Discriminant Analysis (FDA)	10	线性判别分析 Linear Discriminant Analysis (LDA)	1
支持向量机 Support Vector Machine (SVM)	9	马氏距离 Mahalanobis Distance (MAHAL)	1
分类树分析 Classification Tree Analysis (CTA)	8	迭代决策树算法 Multiple Additive Regression Tree (MART)	1
分类回归树 Classification and Regression Tree (CART)	6	空间明晰物种组合模型 Spatially Explicit Species Assemblage Model (SESAM)	1
表面分布区分室模型 Surface Range Envelope (SRE)	6	<i>n</i> 维环境资源模型 <i>n</i> -Dimentional Environment and Resource Model	1
复合型广义相加模型运算系 Mixed GAM Computation Vehicle (MGCV)	3	生态位模型 Niche model	1
		随机预测模型 Random Predictive model	1

MaxEnt预测了几种入侵杂草在我国的潜在分布,并与其他分布模型进行比较,发现MaxEnt的预测效果最好。此后越来越多的中国学者开始应用MaxEnt进行物种分布预测。到2010年,我国学者发表的论文中,应用MaxEnt进行预测的论文比例已经达到50%,而到2016年,超过90%的发表论文应用MaxEnt进行物种分布模拟。

除此之外,应用较为广泛的模型依次是GARP、BIOCLIM、GLM、GAM、RF等(表2)。在这些模型应用中,仅5.2%–7.4%的论文开展了物种潜在分布区的预测,远没有MaxEnt应用广泛。统计年均使用量大于1的物种分布模型(图2)发现,MaxEnt占绝对领先优势。

2.3 物种与环境数据来源

文献中所使用的物种分布数据与环境数据来源多样。物种分布数据是物种分布建模的基础,经统计,文章所使用的物种分布数据主要来源于五方面:一、数据库资料(76.5%),主要包括全球生物多样性信息网格(GBIF: <https://www.gbif.org>)和中国数字植物标本馆(CVH: www.cvh.ac.cn),前者涵盖全球植物分布范围,而后者为中国范围内的物种分布数

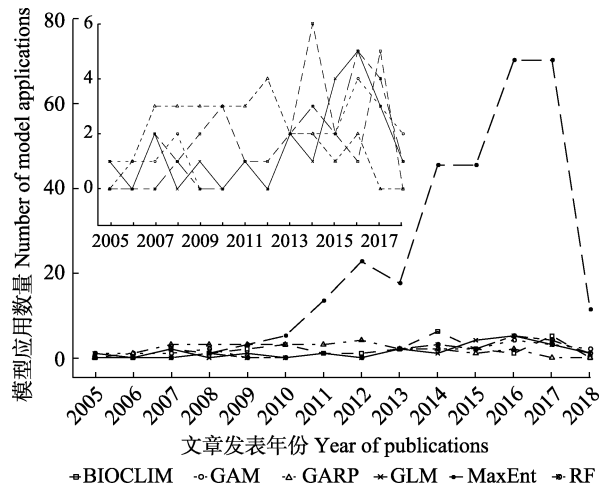


图2 模拟中国植物种常用物种分布模型的年际应用次数。小图为去除MaxEnt之外其他模型的年际变化。模型名称见表2。

Fig. 2 Number of species distribution models used in modeling China's plant species distribution. The small plot is the number of models with MaxEnt excluded. See Table 2 for models.

据。其他数据库资料还包括植物园标本资料和各研究机构标本馆资料等;二、已公开发表的文献中提取(34.2%);三、植物志数据(9.8%),包括中国植物志和各地方植物志;四、植物分布图集资料(6.0%),包括1:100万中华人民共和国植被图和中国木本植

物分布图集; 五、野外实地调查(38.8%), 该方法适用于小尺度范围的植物分布数据的获取。其他物种分布数据来源(1.1%)还包括遥感图像提取、国家重点保护野生植物名录、中国物种信息系统等。由于单一来源的物种分布数据可能存在不准确、不全面的现象, 一些文章会采用两种或多种来源数据相结合进行补充验证, 如植物分布数据库、数字标本馆与野外调查相结合, 以最大程度地保证数据的完整性和准确性。

在统计分析的366篇文献中, 345篇文章的模拟使用了气象数据, 其中193篇文章仅使用了气象数据指标, 占文章总数的52.7%。有135篇文章使用了地形数据, 主要包括海拔、坡度、坡向等, 占比36.9%, 居第二位。其他使用到的环境数据还包括土壤数据、水文数据和植被覆盖度数据等。由于其他环境指标零散而不具有统计意义, 此处仅选用气象数据进行统计分析。物种分布模型研究所使用的气象数据包括热量指标(年平均气温、最冷月平均气温、极端最低温、积温、气温季节性变异系数等)、水分指标(年降水量、降水的季节性和降水的时间、降水的变异系数等)。在全球尺度上的气象要素来源主要为WorldClim (www.worldclim.org)和Climatic Research Unit (CRU: www.cru.uea.ac.uk), 共有251篇文章应用了此数据, 占比68.6%; 全国尺度的气象数据来源主要为中国气象数据网(<http://data.cma.cn>, 曾称为中国气象科学数据共享服务系统、气象数据共享网)、地方气象台站等。通常利用地理信息系统或者其他数学手段, 将获取的气象数据进行地理空间插值, 可得到不同空间分辨率的气象数据图集, 从而应用到物种分布模拟中。

2.4 目标物种

除少数文章只给出了物种数字, 而没有具体物种之外, 在366篇文献中, 物种分布模拟共涉及121科331属562种植物(附录II)。被模拟的植物主要集中在蔷薇科(Rosaceae)、禾本科(Gramineae)、松科(Pinaceae)、菊科(Compositae)以及壳斗科(Fagaceae)。模拟最多的植物为蔷薇科植物, 且多集中在樱属(*Cerasus*)和蔷薇属(*Rosa*)。模拟的植物物种中, 有草本植物235种, 乔木164种, 灌木131种, 藤本13种, 蕨类12种, 藓类7种, 其中也包括24种外来入侵物种, 以及95种珍稀濒危植物(国家I级保护植物14种, II级81种)。

同时我们还发现, 有一些常见种或外来入侵种被多次模拟预测其潜在分布区, 如青海云杉(*Picea crassifolia*)、马尾松(*Pinus massoniana*)、辽东栎(*Quercus wutaishanica*)、紫茎泽兰(*Eupatorium adenophorum*)、加拿大一枝黄花(*Solidago canadensis*)等, 但模拟这些植物的物种分布数据、环境数据、应用模型或研究目的却不尽相同。如以青海云杉为目标物种进行模拟的论文共7篇, Xu等(2009)通过遥感图像提取青海云杉的真实分布点, 应用MaxEnt模拟研究了半干旱地区气候变化对其分布区的影响; 许仲林等(2011)以青海云杉为例提出了一种物种分布模型性能的新评价方法; 彭守璋等(2011)则利用野外调查数据构建生物-地理模型模拟了青海云杉的潜在分布及其资源利用; Xu等(2012)同样利用野外调查数据, 但通过MaxEnt和GARP模型分别进行模拟、预测和比较了青海云杉的分布区; Zhang等(2015)评价了物种分布模型预测青海云杉在内的多种植物分布的一致性; 崔雪晴等(2016)利用MaxEnt模拟了包括青海云杉在内的6个造林树种的适宜分布范围; Peng等(2016)则利用HSM模型分析了青海云杉的潜在分布及其恢复与保护。因此, 针对同一个物种, 利用不同环境数据、不同物种分布模型, 以评价其现状分布、未来恢复与有效保护等不同目的开展模拟, 可从不同角度启发物种分布模拟研究。

2.5 模拟目的

国内学者模拟植物物种分布的主要目的是研究全球变化背景下物种分布和气候之间的关系, 经统计有313篇文章涉及该目的, 占文献总数的85.5%, 主要包括物种的地理分布、潜在分布区(适生区)预测、气候变化对植物分布的影响、物种分布的影响因子分析等多个方面, 以及过去气候变化对植物的影响, 如物种分布区的动态变化和冰川避难所预测等。其他研究目的还包括入侵物种适生区预测(11.5%)、生物多样性保护与管理(6.0%)和物种分布模型方法理论探讨(2.5%)。

3 物种分布模拟存在的问题与未来展望

通过检索2000–2018年间发表的关于中国植物物种分布模拟的366篇文章及摘录相关信息, 定量分析了我国物种分布模型的应用研究态势, 发现我国的工作虽然起步较晚, 但最近10年发展迅速, 物种分布模型受到了越来越多的学者和研究机构的

关注。

当然, 由于物种分布模拟的研究很多, 本文虽然尽可能收集所有已发表的文献, 但仍然有可能存在遗漏现象, 在某种程度上造成上述统计结果的小偏差, 但应该不会影响到结论的准确性。另外, 部分文章开展了几百到几千种植物的模拟(Zhang *et al.*, 2012, 2014, 2017), 但并未罗列出具体的物种名称, 因此这些文章中的物种数据并未纳入统计。无论如何, 本文的集成分析发现, 我国物种分布模型的研究以及应用仍存在一些问题, 需要在今后的工作中不断加强与改进。

3.1 物种分布模型的发展及多模型比较

目前我国学者使用的物种分布模型有33种左右, 国际上的模型数量应该超过40种, 这其中最大熵模型自从2006年发表以来得到了广泛的应用, 最主要原因在于其根据有限的已知信息推断未知分布的数学算法的优势, 以及模型输出数据的连续性, 可以在最大程度上对不同区域的模型适应性进行细微的区分。而且, 多数研究表明, 当数据有限时, 最大熵模型比其他同类模型能够提供更准确的模拟结果(Phillips *et al.*, 2006; 邢丁亮和郝占庆, 2011)。因此, 该模型在我国植物物种分布模拟研究的中后期得到了全面的应用。当然, 也有少数研究的结论相反(罗玫等, 2017), 只是MaxEnt容易操作, 数据处理能力强, 运行时间短, 因此在满足误差要求的前提下, 建议使用该模型; 而且, 该模型目前已经实现了代码开源共享(Phillips *et al.*, 2017)。其他一些较常用的模型, 如遗传算法、生物气候、人工神经网络、广义相加、广义线性、随机森林等模型也在不同领域进行了尝试, 针对某个特殊问题进行多模型相互比较, 或者多模型组合(Ensemble)模拟验证, 也是未来需要进一步关注的。

虽然我国也有学者在探讨物种模拟的理论与机制(张路, 2015; 黄敏毅等, 2016), 但其建立的物种分布模型很少被报道, 说明我们在此方面的工作实力还很弱, 对物种分布模型的原理和算法的理解还不够深入。因此在未来的研究中, 除了继续使用一些模拟精度高的现有物种分布模型之外, 在国际学界公认的物种分布模拟机理与框架下, 继续开发新的物种分布模型, 尤其是推进现有统计性的模型发展为机理性的物种分布模型, 是中国学者努力的方向。

3.2 模型驱动数据的限制性及其本土化

从模型的驱动数据来看, 仅利用气象数据来模拟植物种分布的研究占一半, 而且近2/3的模拟使用了国际上流行的两大全球气候数据库(WorldClim和CRU)数据, 利用本土气候数据的应用仅占1/3。这一方面表明全球气候数据库可免费下载及方便使用, 但缺陷是, 由于全球数据库中的中国气象台站数量较少(New *et al.*, 2002; Hijmans *et al.*, 2005; Harris *et al.*, 2014), 覆盖中国范围的气候数据质量仍需要提高。另一方面, 本土气候数据目前虽可免费下载, 但有诸多限制, 如多为台站原始气象数据, 下载后需要花费大量时间去整理, 而且非成型产品, 无法直接使用, 现有的栅格点插值气象数据的空间分辨率较低(0.5°经纬网格), 这些都阻碍了我国气象数据的广泛使用。因此, 在某种程度上来说, 今后应加强我国本土气候数据的精细化与产品化, 推动其广泛应用。目前也有少数产品可供选择, 如中国气象数据网发布的多种网格点气象数据、中国科学院地理科学与自然资源研究所数据集等(倪健, 2017)。

由此, 基于高精度、高质量的本土驱动数据, 结合我国植物种的生物学与生态学特性, 利用本土模型参数及新的模拟方法, 开发适合中国的物种模拟预测模型, 也是很有必要的。

3.3 气候与环境指标的多元化与数据来源的多样化

目前模拟使用的气候指标多局限在WorldClim数据库提供的19个生物气候指标, 大都是简单的热量和水分指标, 在生态学意义上有一定的局限性, 多种综合指标的使用也是非常必要的, 比如, 综合考虑水分与热量平衡的多种干燥度与湿润度指标, 以及考虑到土壤水量平衡和植被蒸散的有效水分利用指标等(倪健, 2017)。而且, 很多研究将所有气候指标都纳入到模拟中, 然后甄别出其中的一些关键驱动因子, 但这些因子对模拟物种是否具有生态学内涵, 却很少有具体分析。不同植物群对不同气候指标的响应是不一致的, 发展多种水热综合气候指标, 在模拟前综合筛选驱动植物种分布的关键气候因子, 都是今后研究需要注意的。

在模拟区域物种分布时, 来自全球数据库与区域数据库的气候数据精度存在差异, 或者研究有特殊需求, 也可以将不同来源的气候数据应用于模拟同一个物种的地理分布, 以达到相互比较验证的目

的。除了气候数据, 土壤和地形数据也在某些研究中参与到植物种分布的直接模拟(占41.4%), 这是在较小空间尺度上必须考虑的影响植物种分布的重要因素(马松梅等, 2010; Zhang *et al.*, 2015)。因此, 在不同空间尺度应综合考虑不同的环境驱动数据, 今后应加强土壤、地形等方面数据的使用, 在必要的时候水文、人类干扰数据也需要考虑在内。

而从植物种分布的数据来源来看, 来自全球和本土的多源数据库与文献志书、野外直接观测数据均得到广泛使用, 一方面说明物种分布研究的普遍性, 但另一方面也说明各种来源数据都可能存在一定的不准确性, 需要相互支撑验证。近年来, 国内有关物种分布的数据不断积累, 并发表了大量专著。目前研究中使用较多的数据库主要为前面所述的GBIF和CVH, 其他数据来源如中国国家标本资源平台(NSII, <http://www.nsii.org.cn>)、中国木本植物分布图集(方精云等, 2011)等, 以及最近启动建设的“地球大数据科学工程”(CASEarth, <http://www.casearth.com/>)中“生物多样性与生态安全”(BioONE)与“生物多样性科学数据中心”(iFlora, <http://data.iflora.cn>), 其中的植物分布信息都可作为物种分布数据来源, 为物种分布模拟提供了很好的基础。

3.4 模拟植物种的多行业化及对自然植物的重视

在过去研究中, 很多文章发表在综合性的生态学期刊中, 但也有不少发表在行业期刊, 例如中草药和林业期刊(王雷宏等, 2015; 王丹等, 2017), 说明物种分布模型在我国植物种模拟中的基础研究和应用研究是并重的, 既有生态学机理的探讨, 如气候变化背景下物种分布区的扩展, 过去气候情景下物种避难所的发现, 及其气候驱动机制等; 也有中草药和经济植物的适宜种植区筛选, 以扩大资源植物的种植面积, 并提高其产量和质量。

在模拟的目标植物种中, 如果按照生长型分类, 木本植物占52.7%, 草本植物占41.8%。如果按照用途分类, 具有经济价值的物种(园林植物、中草药、农作物、果树等)占比80%以上, 而自然植物所占比重较小。说明物种分布模型在我国的纯生态学研究以及多种行业研究中都发挥着越来越多的作用。在今后的工作中, 需要提高自然植物模拟比例, 可以选择某一科属或者功能类群中的主要植物种, 开展

综合模拟比较, 以更多阐释自然植物的分布现状及其变化趋势。

3.5 物种模拟的理论与应用相结合及推动政策制订

除了上述存在问题所引发的研究方向展望之外, 物种分布模型在我国的继续推广仍需要秉承理论和应用相结合的理念, 在全球环境变化、生物多样性保护等方面继续深入开展研究。并强调基于模拟结果指导政策制订, 为生物多样性保护提供理论依据。

全球变化一直是国内外科学界研究的重点领域, 我国物种分布模型过去在此方面的应用很多, 将来也应该继续更多关注全球变化的理论研究, 尤其是现状气候下的植物种潜在分布和适生区的模拟(周婧等, 2012; 王丹等, 2017), 以及未来气候变化情景下物种分布范围的变迁及其脆弱性和适应性(刘少军等, 2015; Dai *et al.*, 2018), 当然也涉及过去气候变化对物种分布及其冰期避难所的研究(Li *et al.*, 2012; Yan *et al.*, 2012; Wang *et al.*, 2015)。物种分布模型能够直观地提供物种在不同气候时期的分布区大小, 通过对比可得出不同物种对于气候的响应模式(张路, 2015)。古生态学研究也正在吸纳更多物种分布模型的应用, 这也是过去全球变化研究的需求(Svenning *et al.*, 2011)。

生物多样性保护也是当前世界性环境问题, 物种分布模型在此可发挥其从理论到实践, 直至政策建议的一系列作用。模拟珍稀濒危物种的现代适应性及未来变化趋势, 评估生物多样性现状, 筛选物种迁地保护的生境, 从而基于模拟结果而推动一个地区自然保护政策的制订或调整, 比如建立新的自然保护区, 或扩展现有的自然保护区, 以更加有效地保护当地物种(马松梅等, 2010; Wan *et al.*, 2014)。珍稀濒危物种和经济植物的数据少, 无论是对于物种现有的地理分布还是对其潜在分布区的预测都会造成一定的阻碍。而物种分布模型可以利用较少的已知物种分布数据和现有的环境数据, 模拟物种可能的分布地区, 为珍稀濒危植物和经济植物的资源分布调查、就地或迁地保护、人工栽培提供理论依据。

在生物多样性研究中, 外来物种也是一个热门话题, 同样, 物种分布模型也被用来评估物种入侵的环境风险, 从而达到有效管理入侵物种的目标

(王瑞和万方浩, 2016; Wang *et al.*, 2017a)。通过物种分布模型对外来入侵植物的预测, 探讨其扩散化趋势, 可以更好地协助控制外来物种对本地物种生存及自然环境的破坏, 为外来入侵植物的预防和治理提供决策依据。

目前, 物种分布模型也被用于模拟植物群落和植被类型的地理分布(叶永昌等, 2016; Wan *et al.*, 2017)。由于气候变化对植被的影响是长期的, 利用物种分布模型对植被分布的模拟具有一定的时滞性(Svenning & Skov, 2004), 但不可否认它仍然是研究植被与气候关系的有效工具。如果能够突破其仅局限于模拟植物的主要功能类型, 而是如同动态植被模型那样, 更多地模拟各类植被类型, 那么物种分布模型在模拟植被地理分布研究中将会发挥更大的作用(Wang *et al.*, 2017b)。因此, 虽然现有的物种分布模型在生态学与生理学机理上较传统的植被模型有所欠缺(倪健, 2002), 但如同上文所言, 如果能够开发基于生态过程的而非基于统计学信息的机理性物种分布模型, 将它们同时应用于物种和生态系统的模拟, 应该是将来的一个重要发展方向。

同时, 物种分布模型模拟也与人类的生活关系密切, 对经济物种(果树、农作物、中草药、园林花卉等)的模拟比例大于自然植物是最好的证明(He & Zhou, 2012; 赵泽芳等, 2016), 这些研究可为经济植物的栽培引种提供理论依据和技术支持, 以获得最大的经济效益。

因此, 无论是从基础生态学还是应用生态学的角度来看, 物种分布模型将在生态学研究发挥越来越大的作用。无论植物物种分布模型的最终研究目的是什么, 其出发点都是基于已知模拟未知, 这一特性为生态学的研究拓宽了渠道, 从时间尺度与空间尺度上, 都大大增加了研究的丰富程度。

致谢 浙江师范大学重点建设项目(2017XM023和2017PT009)资助。

参考文献

- Araújo MB, Peterson AT (2012). Uses and misuses of bioclimatic envelope modeling. *Ecology*, 93, 1527–1539.
- Busby J (1991). BIOCLIM—A bioclimate analysis and prediction system. *Plant Protection Quarterly*, 6, 8–9.
- Chen XM, Lei YC, Zhang XQ, Jia HY (2012). Effects of sample sizes on accuracy and stability of maximum entropy model in predicting species distribution. *Scientia Silvae Sinicae*, 48(1), 53–59. [陈新美, 雷渊才, 张雄清, 贾宏炎 (2012). 样本量对MaxEnt模型预测物种分布精度和稳定性的影响. *林业科学*, 48(1), 53–59.]
- Cui XQ, Ma HP, Huang GL, Hou M, Xu M, Zheng GQ, Cui BX, Zhuo L, Liao CZ (2016). Research on the land suitable for planting 6 major tree species in Qinghai Province. *Forest Resources Management*, (4), 74–78. [崔雪晴, 马红萍, 黄桂林, 侯盟, 徐明, 郑国强, 崔北祥, 卓凌, 廖成章 (2016). 青海省6个主要树种适宜造林地研究. *林业资源管理*, (4), 74–78.]
- Dai G, Yang J, Lu S, Huang C, Jin J, Jiang P, Yan P (2018). The potential impact of invasive woody oil plants on protected areas in China under future climate conditions. *Scientific Reports*, 8, 1041. DOI: 10.1038/s41598-018-19477-w.
- Elith J, Leathwick JR (2009). Species distribution models: Ecological explanation and prediction across space and time. *Annual Review of Ecology, Evolution, and Systematics*, 40, 677–697.
- Fang JY, Wang ZH, Tang ZY (2011). *Atlas of Woody Plants in China: Distribution and Climate*. Higher Education Press, Beijing. [方精云, 王志恒, 唐志尧 (2011). 中国木本植物分布图集. 高等教育出版社, 北京.]
- Gao B, Wei HY, Guo YL, Gu W (2015). Using GIS and MaxEnt to analyze the potential distribution of *Abies chensiensis*. *Chinese Journal of Ecology*, 34, 843–852. [高蓓, 卫海燕, 郭彦龙, 顾蔚 (2015). 应用GIS和最大熵模型分析秦岭冷杉潜在地理分布. *生态学杂志*, 34, 843–852.]
- Guisan A, Thuiller W (2005). Predicting species distribution: Offering more than simple habitat models. *Ecology Letters*, 8, 993–1009.
- Harris I, Jones PD, Osborn TJ, Lister DH (2014). Updated high-resolution grids of monthly climatic observations—The CRU TS3.10 Dataset. *International Journal of Climatology*, 34, 623–642.
- He Q, Zhou G (2012). The climatic suitability for maize cultivation in China. *Chinese Science Bulletin*, 57, 395–403.
- Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A (2005). Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology*, 25, 1965–1978.
- Huang MY, Kong XQ, Duan RY, Wu GL, Zhang ZX (2016). The basic principle of virtual species and its application to evaluations of species distribution models. *Acta Ecologica Sinica*, 36, 2460–2470. [黄敏毅, 孔晓泉, 段仁燕, 吴甘霖, 张中信 (2016). 虚拟物种的基本原理及其在物种分布模型评估中的应用. *生态学报*, 36, 2460–2470.]
- Jia X, Ma FF, Zhou WM, Zhou L, Yu DP, Qin J, Dai LM (2017). Impacts of climate change on the potential geographical distribution of broadleaved Korean pine (*Pinus koraiensis*) forests. *Acta Ecologica Sinica*, 37, 464–473. [贾翔, 马芳芳, 周旺明, 周莉, 于大炮, 秦静, 代力民

- (2017). 气候变化对阔叶红松林潜在地理分布区的影响. *生态学报*, 37, 464–473.]
- Jiang X, Ni J (2005). Species-climate relationships of 10 desert plant species and their estimated potential distribution range in the arid lands of northwestern China. *Acta Phytocologica Sinica*, 29, 98–107. [蒋霞, 倪健 (2005). 西北干旱区10种荒漠植物地理分布与大气候的关系及其可能潜在分布区的估测. *植物生态学报*, 29, 98–107.]
- Li GQ (2011). *Evaluation the Ecological Niche Models and Predicting Species Potential Distribution Area*. PhD dissertation, Institute of Botany, Chinese Academy of Sciences, Beijing. [李国庆 (2011). 物种生态位模型的适用性评价和物种潜在分布区预测. 博士学位论文, 中国科学院植物研究所, 北京.]
- Li GQ, Liu CC, Liu YG, Yang J, Zhang XS, Guo K (2013). Advances in theoretical issues of species distribution models. *Acta Ecologica Sinica*, 33, 4827–4835. [李国庆, 刘长成, 刘玉国, 杨军, 张新时, 郭柯 (2013). 物种分布模型理论研究进展. *生态学报*, 33, 4827–4835.]
- Li Y, Yan HF, Ge XJ (2012). Phylogeographic analysis and environmental niche modeling of widespread shrub *Rhododendron simsii* in China reveals multiple glacial refugia during the last glacial maximum. *Journal of Systematics and Evolution*, 50, 362–373.
- Liu SJ, Zhou GS, Fang SB, Zhang JH (2015). Effects of future climate change on climatic suitability of rubber plantation in China. *Chinese Journal of Applied Ecology*, 26, 2083–2090. [刘少军, 周广胜, 房世波, 张京红 (2015). 未来气候变化对中国天然橡胶种植气候适宜区的影响. *应用生态学报*, 26, 2083–2090.]
- Luo M, Wang H, Lü Z (2017). Evaluating the performance of species distribution models Biomod2 and MaxEnt using the giant panda distribution data. *Chinese Journal of Applied Ecology*, 28, 4001–4006. [罗玫, 王昊, 吕植 (2017). 使用大熊猫数据评估Biomod2和MaxEnt分布预测模型的表现. *应用生态学报*, 28, 4001–4006.]
- Ma SM, Zhang ML, Zhang HX, Meng HH, Chen X (2010). Predicting potential geographical distributions and patterns of the relic plant *Gymnocarpus przewalskii* using Maximum Entropy and Genetic Algorithm for Rule-set Prediction. *Chinese Journal of Plant Ecology*, 34, 1327–1335. [马松梅, 张明理, 张宏祥, 孟宏虎, 陈曦 (2010). 利用最大熵模型和规则集遗传算法模型预测孑遗植物裸果木的潜在地理分布及格局. *植物生态学报*, 34, 1327–1335.]
- Mao LH, Li Y, Liu C, Fang YM (2017). Predication of potential distribution of *Haplocladium microphyllum* in China based on MaxEnt model. *Chinese Journal of Ecology*, 36, 54–60. [毛俐慧, 李垚, 刘畅, 方炎明 (2017). 基于MaxEnt模型预测细叶小羽藓在中国的潜在分布区. *生态学杂志*, 36, 54–60.]
- New M, Lister D, Hulme M, Makin I (2002). A high-resolution data set of surface climate over global land areas. *Climate Research*, 21, 1–25.
- Ni J (2002). BIOME models: Main principles and applications. *Acta Phytocologica Sinica*, 26, 481–488. [倪健 (2002). BIOME系列模型: 主要原理与应用. *植物生态学报*, 26, 481–488.]
- Ni J (2017). An introduction to bioclimatic factors in global change research. *Quaternary Sciences*, 37, 431–441. [倪健 (2017). 全球变化研究中的生物气候指标. *第四纪研究*, 37, 431–441.]
- Nix H, McMahon J, Mackenzie D (1977). Potential areas of production and the future of pigeon pea and other grain legumes in Australia. In: Wallis ES, Whiteman PC eds. *The Potential for Pigeon Pea in Australia: Proceedings of Pigeon Pea (Cajanus cajan (L.) Millsp.)*. University of Queensland, Queensland. 1–12.
- Peng SZ, Zhao CY, Xu ZL, Ashiq MW (2016). Restoration and conservation potential of destroyed Qinghai spruce (*Picea crassifolia*) forests in the Qilian Mountains of northwest China. *Mitigation and Adaptation Strategies for Global Change*, 21, 153–165.
- Peng SZ, Zhao CY, Xu ZL, Wang C, Liu YY (2011). Potential distribution of Qinghai spruce and assessment of its growth status in the upper reaches of the Heihe River in the Qilian Mountains of China. *Chinese Journal of Plant Ecology*, 35, 605–614. [彭守璋, 赵传燕, 许仲林, 王超, 柳逸月 (2011). 黑河上游祁连山区青海云杉生长状况及其潜在分布区的模拟. *植物生态学报*, 35, 605–614.]
- Phillips SJ, Anderson RP, Dudik M, Schapire RE, Blair ME (2017). Opening the black box: An open-source release of Maxent. *Ecography*, 40, 887–893.
- Phillips SJ, Anderson RP, Schapire RE (2006). Maximum entropy modeling of species geographic distributions. *Ecological Modelling*, 190, 231–259.
- Svenning JC, Fløjgaard C, Marske KA, Nogueira-Bravo D, Normand S (2011). Applications of species distribution modeling to paleobiology. *Quaternary Science Reviews*, 30, 2930–2947.
- Svenning JC, Skov F (2004). Limited filling of the potential range in European tree species. *Ecology Letters*, 7, 565–573.
- Wan JZ, Wang CJ, Han SJ, Yu JH (2014). Planning the priority protected areas of endangered orchid species in northeastern China. *Biodiversity and Conservation*, 23, 1395–1409.
- Wan JZ, Wang CJ, Yu FH (2017). Spatial conservation prioritization for dominant tree species of Chinese forest communities under climate change. *Climatic Change*, 144, 303–316.
- Wang C, Lin HL, Feng QS, Jin CY, Cao AC, He L (2017a). A new strategy for the prevention and control of *Eupatorium adenophorum* under climate change in China. *Sustainability*, 9, 2037. DOI: 10.3390/su9112037.

- Wang D, Wei HY, Yang Y, Shang ZH, Gu W (2017). MaxEnt and GIS for predicting the potential distribution of *Bupleurum marginatum*. *Journal of Chinese Medicinal Materials*, 40, 301–305. [王丹, 卫海燕, 杨洋, 尚忠慧, 顾蔚 (2017). 基于MaxEnt和GIS的竹叶柴胡适生区分布预测. *中药材*, 40, 301–305.]
- Wang J, Ni J (2006). Review of modelling the distribution of plant species. *Journal of Plant Ecology (Chinese Version)*, 30, 1040–1053. [王娟, 倪健 (2006). 植物种分布的模拟研究进展. *植物生态学报*, 30, 1040–1053.]
- Wang LH, Yang JX, Xu XN (2015). Analysis of suitable bioclimatic characteristics of *Pseudolarix amabilis* by using MaxEnt model. *Scientia Silvae Sinicae*, 51(1), 127–131. [王雷宏, 杨俊仙, 徐小牛 (2015). 基于MaxEnt分析金钱松适生的生物气候特征. *林业科学*, 51(1), 127–131.]
- Wang R, Wan FH (2016). Predicting the potential invasive distribution and early-warning monitoring management of *Solanum elaeagnifolium* in China. *Chinese Journal of Ecology*, 35, 1697–1703. [王瑞, 万方浩 (2016). 入侵植物银毛龙葵在中国的适生区预测与早期监测预警. *生态学杂志*, 35, 1697–1703.]
- Wang SY, Xu XT, Shrestha N, Zimmermann NE, Tang ZY, Wang ZH (2017b). Response of spatial vegetation distribution in China to climate changes since the Last Glacial Maximum (LGM). *PLOS ONE*, 12, e0175742. DOI: 10.1371/journal.pone.0175742.
- Wang YH, Jiang WM, Comes HP, Hu FS, Qiu YX, Fu CX (2015). Molecular phylogeography and ecological niche modelling of a widespread herbaceous climber, *Tetrastigma hemsleyanum* (Vitaceae): Insights into Pliocene-Pleistocene range dynamics of evergreen forest in subtropical China. *New Phytologist*, 206, 852–867.
- Xing DL, Hao ZQ (2011). The principle of maximum entropy and its applications in ecology. *Biodiversity Science*, 19, 295–302. [邢丁亮, 郝占庆 (2011). 最大熵原理及其在生态学研究中的应用. *生物多样性*, 19, 295–302.]
- Xu ZL, Peng HH, Peng SZ (2015). The development and evaluation of species distribution models. *Acta Ecologica Sinica*, 35, 557–567. [许仲林, 彭焕华, 彭守璋 (2015). 物种分布模型的发展及评价方法. *生态学报*, 35, 557–567.]
- Xu ZL, Zhao CY, Feng ZD (2011). Species potential distribution models and evaluation based on dissimilarity index of variables of Qinghai spruce (*Picea crassifolia*) in Qilian mountains. *Journal of Lanzhou University (Nature Sciences)*, 47, 55–63. [许仲林, 赵传燕, 冯兆东 (2011). 祁连山青海云杉林物种分布模型与变量相异指数. *兰州大学学报(自然科学版)*, 47, 55–63.]
- Xu ZL, Zhao CY, Feng ZD (2012). Species distribution models to estimate the deforested area of *Picea crassifolia* in arid region recently protected: Qilian Mts. National Natural Reserve (China). *Polish Journal of Ecology*, 60, 515–524.
- Xu ZL, Zhao CY, Feng ZD, Peng HH, Wang C (2009). The impact of climate change on potential distribution of species in semi-arid region: A case study of Qinghai spruce (*Picea crassifolia*) in Qilian Mountain, Gansu Province, China. In: *2009 IEEE International Geoscience and Remote Sensing Symposium*, Cape Town. 412–415.
- Yan HF, Zhang CY, Wang FY, Hu CM, Ge XJ, Hao G (2012). Population expanding with the phalanx model and lineages split by environmental heterogeneity: A case study of *Primula obconica* in subtropical China. *PLOS ONE*, 7, e41315. DOI: 10.1371/journal.pone.0041315.
- Ye YC, Zhou GS, Yin XJ (2016). Changes in distribution and productivity of steppe vegetation in Inner Mongolia during 1961 to 2010: Analysis based on MaxEnt model and synthetic model. *Acta Ecologica Sinica*, 36, 4718–4728. [叶永昌, 周广胜, 殷晓洁 (2016). 1961–2010年内蒙古草原植被分布和生产力变化——基于MaxEnt模型和综合模型的模拟分析. *生态学报*, 36, 4718–4728.]
- Zhang L (2015). Application of MaxEnt in predicting potential distribution of species. *Bulletin of Biology*, 50, 9–12. [张路 (2015). MAXENT最大熵模型在预测物种潜在分布范围方面的应用. *生物学通报*, 50, 9–12.]
- Zhang L, Liu SR, Sun PS, Wang TL, Wang GY, Zhang XD, Wang LL (2015). Consensus forecasting of species distributions: The effects of niche model performance and niche properties. *PLOS ONE*, 10, e0120056. DOI: 10.1371/journal.pone.0120056.
- Zhang MG, Slik JF, Ma KP (2017). Priority areas for the conservation of perennial plants in China. *Biological Conservation*, 210, 56–63.
- Zhang MG, Zhou ZK, Chen WY, Cannon CH, Raes N, Slik JF (2014). Major declines of woody plant species ranges under climate change in Yunnan, China. *Diversity and Distributions*, 20, 405–415.
- Zhang MG, Zhou ZK, Chen WY, Slik JF, Cannon CH, Raes N (2012). Using species distribution modeling to improve conservation and land use planning of Yunnan, China. *Biological Conservation*, 153, 257–264.
- Zhao ZF, Wei HY, Guo YL, Gu W (2016). Potential distribution of *Panax ginseng* and its predicted responses to climate change. *Chinese Journal of Applied Ecology*, 27, 3607–3615. [赵泽芳, 卫海燕, 郭彦龙, 顾蔚 (2016). 人参潜在地理分布以及气候变化对其影响预测. *应用生态学报*, 27, 3607–3615.]
- Zhong GP (2008). *Predicting the Potential Distribution of Invasive Alien Weeds in China*. Master degree dissertation, Southwest University, Chongqing. [钟良平 (2008). 几种外来入侵杂草在我国的潜在分布预测. 硕士学位论文, 西南大学, 重庆.]
- Zhou J, Li QY, Xiao L, Jiang JX, Yi ZL (2012). Potential distribution of *Miscanthus sinensis* and *M. floridulus* in China. *Chinese Journal of Plant Ecology*, 36, 504–510.

[周婧, 李巧云, 肖亮, 蒋建雄, 易自力 (2012). 芒和五节芒在中国的潜在分布. 植物生态学报, 36, 504–510.]

Zhu GP, Liu GQ, Bu WJ, Gao YB (2013). Ecological niche modeling and its applications in biodiversity conservation. *Biodiversity Science*, 21, 90–98. [朱耿平, 刘国卿, 卜文

俊, 高玉葆 (2013). 生态位模型的基本原理及其在生物多样性保护中的应用. 生物多样性, 21, 90–98.]

责任编辑: 王志恒 责任编辑: 李 敏

附录I 物种分布模型在中国植物种分布模拟应用的文献清单

Supplement I Reference list of modelling plant species distribution in China using species distribution models

<http://www.plant-ecology.com/fileup/PDF/cjpe.2018.0237-S1.pdf>

附录II 利用物种分布模型所模拟的中国植物清单

Supplement II Plant species list of China modelled using species distribution models

<http://www.plant-ecology.com/fileup/PDF/cjpe.2018.0237-S2.xlsx>

刘晓彤, 袁泉, 倪健 (2019). 我国植物分布模拟研究现状. 植物生态学报, 43, 273–283. DOI: 10.17521/cjpe.2018.0237

Liu X T, Yuan Q, Ni J (2019). Research advances in modelling plant species distribution in China. Chinese Journal of Plant Ecology, 43, 273–283. DOI: 10.17521/cjpe.2019.0237

<http://www.plant-ecology.com/CN/10.17521/cjpe.2018.0237>

附录I 物种分布模型在中国植物种分布模拟应用的文献清单

Supplement I Reference list of modelling plant species distribution in China using species distribution models

- Bai CK, Wu YM, Cao B, Xu J (2016). Planting regionalization of climate suitability on *Cornus officinalis* in Shaanxi Province based on MaxEnt and GIS. *Journal of Chinese Medicinal Materials*, 39, 289–294. [白成科, 吴永梅, 曹博, 徐军 (2016). 基于MaxEnt和GIS的陕西省山茱萸气候适宜性种植区划研究. 中药材, 39, 289–294.]
- Bai YZ (2009). *The Risk Assessment Technology on Alien Invasive (Sole Invasive Species, Flaveria bidentis)*. Master degree dissertation, Nanjing Agricultural University, Nanjing. [白艺珍 (2009). 外来入侵物种(红火蚁, 黄顶菊)适生性风险评估技术研究. 硕士学位论文, 南京农业大学, 南京.]
- Bi YF, Xu JC, Li QH, Yang YP, Yang XF (2013). Applying BioMod for model-ensemble in species distributions: A case study for *Tsuga chinensis* in China. *Plant Diversity and Resources*, 35, 647–655. [毕迎凤, 许建初, 李巧宏, 杨永平, 杨雪飞 (2013). 应用BioMod集成多种模型研究物种的空间分布——以铁杉在中国的潜在分布为例. 植物分类与资源学报, 35, 647–655.]
- Cao B, Bai CK, Zhang LL, Li GS, Mao MC (2016). Modeling habitat distribution of *Cornus officinalis* with Maxent modeling and fuzzy logics in China. *Journal of Plant Ecology*, 9, 742–751.
- Cao MC (2005). *Study on Simulating the Geographical Distributions of Common Tree Species in China Based on Generalized Models and Classification and Regression Tree*. Master degree dissertation, Institute of Botany, Chinese Academy of Sciences, Beijing. [曹铭昌 (2005). 基于广义模型和分类回归树的中国常见树种地理分布模拟研究. 硕士学位论文, 中国科学院植物研究所, 北京.]
- Cao XF (2010). *The Prediction of Potential Suitable Distribution and Risk Assessment of the Alien Invasive Plant Flaveria bidentis (L.) in China*. Master degree dissertation, Nanjing Agricultural University, Nanjing. [曹向锋 (2010). 外来入侵植物黄顶菊在中国潜在适生区预测及其风险评估. 硕士学位论文, 南京农业大学, 南京.]
- Cao XF, Qian GL, Hu BS, Liu FQ (2010). Prediction of potential suitable distribution area of *Flaveria bidentis* in China based on niche models. *Chinese Journal of Applied Ecology*, 21, 3063–3069. [曹向锋, 钱国良, 胡白石, 刘凤权 (2010). 采用生态位模型预测黄顶菊在中国的潜在适生区. 应用生态学报, 21, 3063–3069.]
- Che L, Cao B, Bai CK, Wang JJ, Zhang LL (2014). Predictive distribution and habitat suitability assessment of *Notholirion bulbuliferum* based on MaxEnt and ArcGIS. *Chinese Journal of Ecology*, 33, 1623–1628. [车乐, 曹博, 白成科, 王娟娟, 张琳琳 (2014). 基于MaxEnt和ArcGIS对太白米的潜在分布预测及适宜性评价. 生态学杂志, 33, 1623–1628.]
- Chen GK, Kery M, Zhang JL, Ma KP (2009). Factors affecting detection probability in plant distribution studies. *Journal of Ecology*, 97, 1383–1389.
- Chen H, Chen LJ (2007). Predicting the potential distribution of invasive exotic species using GIS and remote sensing. *Journal of Remote Sensing*, 11, 426–432. [陈浩, 陈利军 (2007). 利用遥感和GIS的方法预测外来入侵物种的潜在分布. 遥感学报, 11, 426–432.]
- Chen H, Chen LJ, Albright TP (2007). Predicting the potential distribution of invasive exotic species using GIS and information-theoretic approaches: A case of ragweed (*Ambrosia artemisiifolia* L.) distribution in China. *Chinese Science Bulletin*, 52, 1223–1230.
- Chen H, Chen LJ, Thomas PA (2007). Using GIS and information theory to predict the potential distribution of alien invasive species in China, by using *Ambrosia artemisiifolia* L. as sample. *Chinese Science Bulletin*, 52, 555–561. [陈浩, 陈利军, Thomas PA (2007). 以豚草为例利用GIS和信息理论的方法预测外来入侵物种在中国的潜在

分布. 科学通报, 52, 555–561.]

- Chen JJ, Yan YY, Cong RH, Liu QF, Liu Y, Ding Y, Niu JM, Zhang Q (2016). Prediction of potential distribution of *Stipa breviflora* in China based on MaxEnt model. *Chinese Journal of Grassland*, 38(5), 78–84. [陈俊俊, 燕亚媛, 丛日慧, 刘庆福, 刘洋, 丁勇, 牛建明, 张庆 (2016). 基于MaxEnt模型的短花针茅在中国的潜在分布区研究及预估. 中国草地学报, 38(5), 78–84.]
- Chen L. Prediction of the Distribution Area for *Eichhornia Crassipes* Based on Ecological Niche Model. Master dissertation, Shandong Nornal University, Jinan. [陈璐 (2015). 基于生态位模型的凤眼莲分布区预测分析. 硕士学位论文, 山东师范大学, 济南.]
- Chen LL, Yu Y, He XJ (2008). Historical invasion and expansion process of *Alternanthera philoxeroides* and its potential spread in China. *Biodiversity Science*, 16, 578–585. [陈立立, 余岩, 何兴金 (2008). 喜旱莲子草在中国的入侵和扩散动态及其潜在分布区预测. 生物多样性, 16, 578–585.]
- Chen LN, Wang SX, Zhen RL, Hu SQ (2016). Study on suitable growing area of wild Cherries in Zhejiang Province based on MaxEnt model. *Journal of Zhejiang Sci-Tech University (Natural Sciences)*, 35, 122–128. [陈丽娜, 王声晓, 郑若兰, 胡绍庆 (2016). 基于 MaxEnt 模型的野生樱浙江适生区研究. 浙江理工大学学报, 35, 122–128.]
- Chen LU, Peng SL, Yang B (2015). Predicting alien herb invasion with machine learning models: biogeographical and life-history traits both matter. *Biological Invasions*, 17, 2187–2198.
- Chen TZ, Liu JH, Zhou XJ, Zhang M, Gu B, Liao JS (2017). Potential distribution prediction and suitability evaluation of *Albizia julibrissin* durazz. based on MaxEnt and ArcGIS. *Northern Horticulture*, 16, 191–195. [陈铁柱, 刘建辉, 周先建, 张美, 辜彬, 廖述吉 (2017). 基于 MaxEnt 和 ArcGIS 预测合欢潜在分布及适宜性评价. 北方园艺, 16, 191–195.]
- Chen TZ, Zhang T, Fang QM, Wen FY, Yang YX, Zhang H, Xue D (2017). Prediction of potential distribution of *Paris polyphylla* Smith var. *chinensis* (Franch.) Hara by using MaxEnt and ArcGIS, and the evaluation of model suitability. *Journal of Chinese Medicinal Materials*, 40, 803–806. [陈铁柱, 张涛, 方清茂, 文飞燕, 杨玉霞, 张浩, 薛丹 (2017). 基于 MaxEnt 和 ArcGIS 预测华重楼潜在分布及适宜性评价. 中药材, 40, 803–806.]
- Chen XM, Lei YC, He Z (2010). Prediction of the distribution of clustered species by using MaxEnt mode. In: *The 9th China Forestry Youth Academic Annual Conference*, Chendu. [陈新美, 雷渊才, 何铮 (2010). MaxEnt 模型对群团状物种分布的预测. 第九届中国林业青年学术年会论文摘要集, 成都.]
- Chen XM, Lei YC, Zhang XQ, Jia HY (2012). Effects of sample sizes on accuracy and stability of maximum entropy model in predicting species distribution. *Scientia Silvae Sinicae*, 48, 53–59. [陈新美, 雷渊才, 张雄清, 贾宏炎 (2012). 样本量对 MaxEnt 模型预测物种分布精度和稳定性的影响. 林业科学, 48, 53–59.]
- Chen YH, Shen Y, Chen Q, Che LP, Guo SL (2015). On climate adaptability of nine species of *Adiantum* ornamental ferns in 34 provincial capital cities, China. *Journal of Shanghai Normal University (Natural Sciences)*, 44, 638–644. [陈云辉, 沈阳, 陈倩, 车丽萍, 郭水良 (2015). 九种铁线蕨属植物对中国主要城市的气候适应性研究. 上海师范大学学报, 44, 638–644.]
- Chen,J, Shen Y, Guo SL (2015). Influences of climatic warming on potential distribution regions of *Calymperes* in China. *Ecological Science*, 34, 9–16. [程军, 沈阳, 郭水良 (2015). 气候变暖对花叶蕨属植物在中国的潜在分布范围影响的预测. 生态科学, 34, 9–16.]
- Chung MY, Vu SH, López-Pujol J, Herrando-Moraira S, Son SW, Suh GU, Le HTQ, Chung MG (2018). Comparison of genetic variation between northern and southern populations of *Lilium cernuum* (Liliaceae): implications for Pleistocene refugia. *PloS One*, 13, e0190520.
- Cui JL (2015). Potential Impacts of Climate Change on the Distribution of Three Commonly Medicinal Plants. Master dissertation, Shaanxi Normal University, Xi'an. [崔晋亮 (2015). 气候变化对三种常用药用植物分布的潜在影响. 硕士学位论文, 陕西师范大学, 西安.]

- Cui JL, Wei HY, Sang MJ, Zhu LN, Gu W (2015). Prediction of potential distribution of blueberry based on maximum entropy model. *Shandong Agricultural Science*, 9, 36–41. [崔晋亮, 卫海燕, 桑满杰, 朱俐南, 顾蔚 (2015). 基于最大熵模型的蓝莓潜在分布区预测. *山东农业科学*, 9, 36–41.]
- Cui XQ, Ma HP, Huang GL, Hou M, Xu M, Zheng GQ, Cui BX, Zhuo L, Liao CZ (2016). Research on the land suitable for planting 6 major tree species in Qinghai Province. *Forest Resources Management*, (4), 74–78. [崔雪晴, 马红萍, 黄桂林, 侯盟, 徐明, 郑国强, 崔北祥, 卓凌, 廖成章 (2016). 青海省 6 个主要树种适宜造林地研究. *林业资源管理*, (4), 74–78.]
- Cui XY, Wang WJ, Yang XQ, Li S, Qin SY, Rong J (2016). Potential distribution of wild *Camellia oleifera* based on ecological niche modeling. *Biodiversity Science*, 24, 1117–1128. [崔相艳, 王文娟, 杨小强, 李述, 秦声远, 戎俊 (2016). 基于生态位模型预测野生油茶潜在分布. *生物多样性*, 24, 1117–1128.]
- Cui ZJ, Lei FS, Lu YY, Jin L, Ma Y, Wang ZH. Study of potential distribution regions of *Gentiana dahurica*. *Modern Chinese Medicine*, 19, 815–820. [崔治家, 雷丰顺, 卢有媛, 晋玲, 马毅, 王振恒 (2017). 达乌里秦艽潜在适生分布区研究. *中国现代中药*, 19, 815–820.]
- Dai GH, Yang J, Lu SR, Huang CH, Jin J, Jiang P, Yan PB (2018). The potential impact of invasive woody oil plants on protected areas in China under future climate conditions. *Scientific Reports*, 8, 1041.
- Deng F, Li XB, Wang H, Zhang M, Li X, Li RH (2014). The suitability of geographic distribution and the dominant factors of alfalfa based on MaxEnt model in Xilin Gol. *Pratacultural Science*, 31, 1840–1847. [邓飞, 李晓兵, 王宏, 张蒙, 李旭, 李瑞华 (2014). 基于 MaxEnt 模型评价紫花苜蓿在锡林郭勒盟的分布适宜性及主导因子. *草业科学*, 31, 1840–1847.]
- Deng X (2013). The Application of Elman Artificial Neural Networks for Modelling the Distribution of *Pinus Bungeana* in Present and Future. Master dissertation, Northwest University, Xi'an. [邓鑫 (2013). 基于 Elman 神经网络的白皮松潜在适生区估测及未来分布趋势研究. 硕士学位论文, 西北大学, 西安.]
- Dilidaer Y (2014). Suitable Areas and Risk Analysis of Several Invasive Plants in Yili Region. Master dissertation, Xinjiang University, Wulumuqi. [迪丽达尔·亚森江 (2014). 伊犁地区入侵植物物种的适生区分析及其风险评估. 硕士学位论文, 新疆大学, 乌鲁木齐.]
- Dong X, Chen XZ, Lou YX, Guo SL (2013). Prediction of potential invasion range of alien plant *Peperomia pellucida* in China. *Journal of Zhejiang University (Agricultural and Life Science Edition)*, 39, 621–628. [董旭, 陈秀芝, 娄玉霞, 郭水良 (2013). 外来入侵植物草胡椒在我国的潜分布范围预测. *浙江大学学报 (农业与生命科学版)*, 39, 621–628.]
- Du ZX (2010). Prediction of Potential Geographical Distribution and Invasion Risk Assessment to Natural Ecosystem of *Rhus Typhina*. Master dissertation, Shandong Agricultural University, Taian. 杜中修 (2010). 火炬树适生区预测及对自然生态系统的入侵风险评估. 硕士学位论文, 山东农业大学, 泰安.
- Du ZX, Wu J, Meng XX, Li JH, Huang LF (2017). Predicting the global potential distribution of four endangered *Panax* species in middle-and low-latitude regions of china by the geographic information system for global medicinal plants (GMPGIS). *Molecules*, 22, 1630.
- Du ZX, Zhen YQ, Lu FD, Zhang CH (2011). Prediction of potential geographical distribution of *Rhus typhina* in China. *Guangdong Agricultural Sciences*, 38, 50–52+221. [杜中修, 郑勇奇, 鲁法典, 张川红 (2011). 火炬树在我国的适生区预测. *广东农业科学*, 38, 50–52+221.]
- Duan JQ, Zhou GS (2011). Potential distribution of rice in china and its climate characteristics. *Acta Ecologica Sinica*, 31, 6659–6668. [段居琦, 周广胜 (2011). 中国水稻潜在分布及其气候特征. *生态学报*, 31, 6659–6668.]
- Duan JQ, Zhou GS (2012). A preliminary study of planting northern boundary of single harvest rice in China. *Acta Meteorologica Sinica*, 70, 1165–1172. [段居琦, 周广胜 (2012). 中国单季稻种植北界的初步研究. *气象学报*, 70, 1165–1172.]
- Duan JQ, Zhou GS (2012). Climatic suitability of double rice planting regions in China. *Scientia Agricultura Sinica*, 45,

- 218–227. [段居琦, 周广胜 (2012). 中国双季稻种植区的气候适宜性研究 中国农业科学, 45, 218–227.]
- Duan RY, Kong XQ, Huang MY, Fan WY, Wang ZG (2014). The predictive performance and stability of six species distribution models. *PLoS One*, 9, e112764.
- Fan XH, You Y (2010). Analysis of the fitness of *Cabomba caroliniana* A.Gray in China and Xinjiang. In: Proceedings of the 2010 in and out Plant Quarantine Symposium, Hefei, 97–100. [范晓虹, 尤扬 (2010). 外来有害生物水盾草在中国和新疆适生性分析. 2010年进出境植物检疫学术研讨会论文集, 合肥, 97–100.]
- Fang F, Zhang CX, Huang HJ, Li Y, Chen JC, Yang L, Wei SH (2013). Potential distribution of Tausch's goatgrass (*Aegilops tauschii*) in both China and the rest of the world as predicted by MaxEnt. *Acta Prataculturae Sinica*, 22, 62–70. [房锋, 张朝贤, 黄红娟, 李燕, 陈景超, 杨龙, 魏守辉 (2013). 基于 MaxEnt 的麦田恶性杂草节节麦的潜在分布区预测. 草业学报, 22, 62–70.]
- Fu GQ, Xu XY, Ma JP, Xu MS, Liu J, Ding AQ (2016). Responses of *Haloxylon ammodendron* potential geographical distribution to the hydrothermal conditions under MaxEnt model. *Pratacultural Science*, 33, 2173–2179. [付贵全, 徐先英, 马剑平, 徐梦莎, 刘江, 丁爱强 (2016). 基于 MaxEnt 下梭梭潜在地理分布对水热条件的响应. 草业科学, 33, 2173–2179.]
- Fu XY, Ze SZ, Zhou X, Ji M (2015). Distribution prediction and assessment of *Mikania micrantha* in Yunnan Province based on MaxEnt model. *Guangdong Agricultural Sciences*, 42, 159–162. [付小勇, 泽桑梓, 周晓, 季梅 (2015). 基于 MaxEnt 的云南省薇甘菊分布预测及评价. 广东农业科学, 42, 159–162.]
- Fu ZZ, Li YH, Zhang KM, Li Y (2014). Molecular data and ecological niche modeling reveal population dynamics of widespread shrub *Forsythia suspensa* (Oleaceae) in China's warm-temperate zone in response to climate change during the Pleistocene. *BMC Evolutionary Biology*, 14, 114.
- Gao B, Gao MS, Dong JF (2016). Planting distribution and suitability assessment of single-season rice based on MaxEnt and ArcGIS in Shaanxi Province. *Journal of China Agricultural University*, 21, 8–15. [高蓓, 高茂盛, 董金芳 (2016). 基于最大熵模型和 ArcGIS 的陕西省单季稻种植分布预测及适宜性. 中国农业大学学报, 21, 8–15.]
- Gao B, Hu N, Guo YL, Gu W, Zou JY (2017). Comparison of the potential geographical distribution of foxtail millet (*Setaria italica*) predicted by multi models. *Chinese Journal of Applied Ecology*, 28, 3331–3340. [高蓓, 胡凝, 郭彦龙, 顾蔚, 邹继业 (2017). 中国谷子潜在地理分布的多模型比较. 应用生态学报, 28, 3331–3340.]
- Gao B, Wei HY, Guo YL, Gu W (2015). Using GIS and MaxEnt to analyze the potential distribution of *Abies chensiensis*. *Chinese Journal of Ecology*, 34, 843–852. [高蓓, 卫海燕, 郭彦龙, 顾蔚 (2015). 应用 GIS 和最大熵模型分析秦岭冷杉潜在地理分布. 生态学报, 34, 843–852.]
- Gao WQ, Wang XF, Jiang ZP, Liu JF (2016). Impact of climate change on the potential geographical distribution pattern and dominant climatic factors of *Quercus variabilis*. *Acta Ecologica Sinica*, 36, 4475–4484. [高文强, 王小菲, 江泽平, 刘建峰 (2016). 气候变化下栓皮栎潜在地理分布格局及其主导气候因子. 生态学报, 36, 4475–4484.]
- Gong W, Liu WZ, Gu L, Kaneko S, Koch MA, Zhang DX (2016). From glacial refugia to wide distribution range: demographic expansion of *Loropetalum chinense* (Hamamelidaceae) in Chinese subtropical evergreen broadleaved forest. *Organisms Diversity Evolution*, 16, 23–38.
- Gong W, Xia Q, Chen HF, Yu XH, Wu F (2015). Prediction of potential distributions of *Bretschneidera sinensis*, an rare and endangered plant species in China. *Journal of South China Agricultural University*, 36, 98–104. [龚维, 夏青, 陈红锋, 俞新华, 伍菲 (2015). 珍稀濒危植物伯乐树的潜在适生区预测. 华南农业大学学报, 36, 98–104.]
- Gong Y, Jing PF, Wei YK, Huang WC, Cui LJ (2014). Potential distribution of *Bletilla striata* (Orchidaceae) in China and its climate characteristics. *Plant Diversity and Resources*, 36, 237–244. [龚晔, 景鹏飞, 魏宇昆, 黄卫昌, 崔浪军 (2014). 中国珍稀药用植物白及的潜在分布与其气候特征. 植物分类与资源学报, 36, 237–244.]
- Guan BC, Chen W, Liu X, Cai QY, Liu YZ, Ge G (2016). Distribution pattern and glacial refugia of *Cornus kousa* subsp. *chinensis* based on MaxEnt model and GIS. *Acta Botanica Boreali-Occidentalia Sinica*, 36, 2541–2547. [管毕财, 陈微, 刘想, 蔡奇英, 刘以珍, 葛刚 (2016). 四照花物种分布格局模拟及冰期避难所推测. 西北植物学报,

36, 2541–2547.]

- Guo J, Liu XP, Zhang Q, Zhang DF, Xie CX, Liu X (2017). Prediction for the potential distribution area of *Codonopsis pilosula* at global scale based on Maxent model. *Chinese Journal of Applied Ecology*, 28, 992–1000. [郭杰, 刘小平, 张琴, 张东方, 谢彩香, 刘霞 (2017). 基于 Maxent 模型的党参全球潜在分布区预测. *应用生态学报*, 28, 992–1000.]
- Guo SL, Gao PL, Lou YX (2011). Prediction of potential invasive range of quarantine weed *Lactuca serriola* in China by MaxEnt model. *Journal of Shanghai Jiaotong University (Agricultural Science)*, 29, 15–19. [郭水良, 高平磊, 娄玉霞 (2011). 应用MaxEnt模型预测检疫性杂草毒莠苣在中国的潜分布范围. *上海交通大学学报 (农业科学版)*, 29, 15–19.]
- Guo XD, Wang HF, Bao L, Wang TM, Bai WN, Ye JW, Ge JP (2014). Evolutionary history of a widespread tree species *Acer mono* in East Asia. *Ecology Evolution*, 4, 4332–4345.
- Guo YL, Wei HY, Lu CY, Gao B, Gu W (2016). Predictions of potential geographical distribution and quality of *Schisandra sphenanthera* under climate change. *PeerJ*, 4, e2554.
- Guo YL, Wei HY, Lu CY, Zhang HL, Gu W (2014). Predictions of potential geographical distribution of *Sinopodophyllum hexandrum* under climate change. *Chinese Journal of Plant Ecology*, 38, 249–261. [郭彦龙, 卫海燕, 路春燕, 张海龙, 顾蔚 (2014). 气候变化下桃儿七潜在地理分布的预测. *植物生态学报*, 38, 249–261.]
- Hao CY, Rui F, Ribeiro MC, Tan LH, Wu HS, Yang JF, Zheng WQ, Huan Y (2012). Modeling the potential geographic distribution of black pepper (*Piper nigrum*) in Asia using GIS tools. *Journal of Integrative Agriculture*, 11, 593–599.
- Hao CY, Tan LH, Fan R, Chen HP, Wu HS, Li ZG, Wu G (2011). Predicting potential geographical distributions of medicinal plant *Piper hainanense* using maximum entropy. *Chinese Journal of Tropical Crops*, 32, 1561–1566. [郝朝运, 谭乐和, 范睿, 陈海平, 邬华松, 李志刚, 吴刚 (2011). 利用最大熵模型预测药用植物海南茛的潜在地理布局, 32, 1561–1566.]
- He QJ, Zhou GS (2011). Climatic suitability of potential summer maize planting zones in China. *Acta Geographica Sinica*, 66, 1443–1450. [何奇瑾, 周广胜 (2011). 我国夏玉米潜在种植分布区的气候适宜性研究. *地理学报*, 66, 1443–1450.]
- He QJ, Zhou GS (2012). Climatic suitability of potential spring maize cultivation distribution in China. *Acta Ecologica Sinica*, 32, 3931–3939. [何奇瑾, 周广胜 (2012). 我国春玉米潜在种植分布区的气候适宜性. *生态学报*, 32, 3931–3939.]
- He QJ, Zhou GS (2012). The climatic suitability for maize cultivation in China. *Chinese Science Bulletin*, 57, 395–403.
- He QJ, Zhou GS (2016). Climate-associated distribution of summer maize in China from 1961 to 2010. *Agriculture, Ecosystems Environment*, 232, 326–335.
- He SL, Meng J, Hong MW, Li Y, Zhang X, Yang Y (2015). MaxEnt-based prediction of potential distribution areas of *Lonicera japonica* and *Lonicera macranthoides*. *Journal of Yunnan Agricultural University*, 30, 777–783. [贺水莲, 孟静, 洪明伟, 李源, 张洵, 杨扬 (2015). 基于 MaxEnt 软件的忍冬与灰毡毛忍冬的适生分布区预测. *云南农业大学学报*, 30, 777–783.]
- He ST, Bai BY, Dan JH, Zhao JY, Gao XQ, Jing PF (2014). Prediction of potential distribution areas of *Salvia bowleyana* Dunn. in China based on MaxEnt and suitability analysis. *Journal of Anhui Agricultural Sciences*, 441, 2311–2314. [何淑婷, 白碧玉, 但佳惠, 赵静滢, 高馨琪, 景鹏飞 (2014). 基于MaxEnt的南丹参在中国的潜在分布区预测及适生性分析. *安徽农业科学*, 441, 2311–2314.]
- He XH, Wen ZM, Wang JX (2008). Spatial distribution of major grassland species and its relations to environment in Yanhe River catchment based on generalized additive model. *Chinese Journal of Ecology*, 27, 1718–1724. [赫晓慧, 温仲明, 王金鑫 (2008). 基于 GAM 模型的延河流域主要草地物种空间分布及其与环境的关系. *生态学报*, 27, 1718–1724.]

- He YX (2015). Simulation the Geographic Distribution of Five *Lindera* Species and Analysis Their Dominant Climatic Factors. Master dissertation, Northwest A&F University, Yangling. [贺怡娴 (2015). 5 种山胡椒属植物的地理分布模拟及主导气候因子分析. 西北农林科技大学, 杨凌.]
- Hu JZ, Zhang YL, Yu HB (2015). Simulation of *Stipa purpurea* distribution pattern on Tibetan Plateau based on MaxEnt model and GIS. *Chinese Journal of Applied Ecology*, 26, 505–511. [胡忠俊, 张镔锂, 于海彬 (2015). 基于 MaxEnt 模型和 GIS 的青藏高原紫花针茅分布格局模拟. 应用生态学报, 26, 505–511.]
- Hu LL, Zhang HY, Qin L, Yan BQ (2012). Current distribution of *Schisandra chinensis* in China and its predicted responses to climate change. *Chinese Journal of Applied Ecology*, 23, 2445–2450. [胡理乐, 张海英, 秦岭, 闫伯前 (2012). 中国五味子分布范围及气候变化影响预测. 应用生态学报, 23, 2445–2450.]
- Hu X, Guo W, Wu FC, Liu N (2015). Application of MaxEnt ecology model in near-nature forestry plant introduction regionalization with *Hedychium coccineum* as an exampl. *Guihai*, 35, 325–330. [胡秀, 郭微, 吴福川, 刘念 (2015). MaxEnt 生态学模型在野生植物近自然林引种区划中的应用——以红姜花为例. 广西植物, 35, 325–330.]
- Hu X, Wu FC, Guo W (2013). Prediction of potential *Hedychium villosum* Wall. introduction area based on MaxEnt ecologic niche model. *Journal of Chinese Urban Forestry*, 11, 28–31. [胡秀, 吴福川, 郭微 (2013). 基于 MaxEnt 生态学模型的毛姜花潜在园林引种区预测. 中国城市林业, 11, 28–31.]
- Hu X, Wu FC, Guo W, Liu N (2014). Identincation of potential cultivation region for *Santalum album* in China by the MaxEnt ecologic niche model. *Scientia Silvae Sinicae*, 50, 27–33. [胡秀, 吴福川, 郭微, 刘念 (2014). 基于 MaxEnt 生态学模型的檀香在中国的潜在种植区预测. 林业科学, 50, 27–33.]
- Hu X, Yang JW, Gao LX, Liu N (2014). The potential introduction area prediction about *Hedychium puerense* based on MaxEnt ecologic niche model in landscape. *Landscape Plant Study & Application*, 36, 65–68. [胡秀, 杨剑文, 高丽霞, 刘念 (2014). 基于 MaxEnt 生态学模型对洱姜花潜在的园林引种区进行预测. 广东园林, 36, 65–68.]
- Hu XG, Jin YQ, Wang XR, Mao JF, Li Y (2015). Predicting impacts of future climate change on the distribution of the widespread conifer *Platycladus orientalis*. *PloS One*, 10, e0132326.
- Hu XG, Wang TL, Liu SS, Jiao SQ, Jia KH, Zhou SS, Jin YQ, Li Y, El-Kassaby YA, Mao JF (2017). Predicting future seed sourcing of *Platycladus orientalis* (L.) for future climates using climate niche models. *Forests*, 8, 471.
- Hu ZH, Yi ZL, Chen ZY, Ma LB (2017). Potential suitability analysis of *Salvia Hispanica* L. in China based on Maxtent ecological niche models. *Journal of Tongren University*, 19, 5–10. [胡忠红, 易自力, 陈智勇, 马乐邦 (2017). 基于 Maxent 生态位模型的莢欧鼠尾草在中国潜在的适生性分析. 铜仁学院学报, 19, 5–10.]
- Huang YJ, Jacques F MB, Su T, Ferguson D K, Tang H, Chen WY, Zhou ZK (2015). Distribution of Cenozoic plant relicts in China explained by drought in dry season. *Scientific Reports*, 5, 14212.
- Huo Y, Li YN, Zhu ZL (2015). Simulation of potential distributions and future distributions for four evergreen trees. *Chinese Wild Plant Resources*, 34, 72–76. [火艳, 李燕楠, 祝遵凌 (2015). 四种常绿乔木潜在及未来分布区模拟研究. 中国野生植物资源, 34, 72–76.]
- Jia X, Ma FF, Zhou L, Yu DP, Qin J, Dai LM (2017). Impacts of climate change on the potential geographical distribution of broadleaved Korean pine (*Pinus koraiensis*) forests. *Acta Ecologica Sinica*, 37, 464–473. [贾翔, 马芳芳, 周旺明, 周莉, 于大炮, 秦静, 代力民 (2017). 气候变化对阔叶红松林潜在地理分布区的影响. 生态学报, 37, 464–473.]
- Jian JX, Jiang H, Peng W, Zhang LJ, Lu XH, Xu JH, Zhang XY, Wang Y (2013). Evaluating the impact of soil factors on the potential distribution of *Phyllostachys edulis* (bamboo) in China based on the species distribution model. *Chinese Journal of Plant Ecology*, 37, 631–640. [金佳鑫, 江洪, 彭威, 张林静, 卢学鹤, 徐建辉, 张秀英, 王颖 (2013). 基于物种分布模型评价土壤因子对我国毛竹潜在分布的影响. 植物生态学报, 37, 631–640.]
- Jiang HJ, Liu T, Li L, Zhao Y, Pei L, Zhao JC (2016). Predicting the potential distribution of *Polygala tenuifolia* Willd. under climate change in China. *PloS One*, 11, e0163718.

- Jiang JF, Fan XC, Zhang Y, Wei W, Kang DM, Liu CH (2014). Modeling the geographic distribution of three endangered *Vitis* species in China. *Chinese Journal of Ecology*, 33, 1615–1622. [姜建福, 樊秀彩, 张颖, 魏伟, 康定明, 刘崇怀 (2014). 中国三种濒危葡萄属 (*Vitis* L.) 植物的地理分布模拟. *生态学杂志*, 33, 1615–1622.]
- Jiang JF, Kell S, Fan XC, Zhang Y, Wei W, Kang DM, Maxted N, Ford-Lloyd B, Liu CH (2015). The wild relatives of grape in China: Diversity, conservation gaps and impact of climate change. *Agriculture, Ecosystems Environment* 209, 155–163.
- Jiang XL, Deng M, Li Y (2016). Evolutionary history of subtropical evergreen broad-leaved forest in Yunnan Plateau and adjacent areas: An insight from *Quercus schottkyana* (Fagaceae). *Tree Genetics Genomes*, 12, 104.
- Jiang YB, Zhang YJ (2016). Distribution of plant functional groups in the natural grasslands of Xizang, China. *Plant Science Journal*, 34, 220–229. [姜炎彬, 张扬建 (2016). 西藏天然草地植物功能群分布的初步研究. *植物科学学报*, 34, 220–229.]
- Jiao CC, Zhou DM (2014). Modeling the spatial distribution of *Carex pseudocuraica* in a freshwater marsh, northeast China. *Wetlands*, 34, 267–276.
- Jing PF (2013). Resource Survey and Diversity Evaluation of Sect. *Drymosphace*. Master dissertation, Shaanxi Normal University, Xi'an. [景鹏飞 (2013). 丹参组药用植物资源调查和多样性评价研究. 硕士学位论文, 陕西师范大学, 西安.]
- Jing PF, Wu KY, Gong Y, Han LM, Cui LJ (2015). Prediction of potential geological distribution of *Asarum* in China by Maxent model. *Plant Diversity and Resources*, 37, 349–356. [景鹏飞, 武坤毅, 龚晔, 韩立敏, 崔浪军 (2015). 药用植物细辛在中国的潜在适生区分布. *植物分类与资源学报*, 37, 349–356.]
- Ju B (2014). On Geographical Distribution Patterns and Potential Region Prediction of Partial Moss Taxa in China. Master dissertation, Shanghai Normal University, Shanghai. [巨斌 (2014). 中国藓类植物部分类群地理分布格局及其分布区预测的研究. 硕士学位论文, 上海师范大学, 上海.]
- Kang CZ, Wang QQ, Zhou T, Jiang WK, Xiao CH, Xie Y (2014). Study on ecological suitability regionalization of *Eucommia ulmoides* in Guizhou. *Journal of Chinese Medicinal Materials*, 37, 760–766. [康传志, 王青青, 周涛, 江维克, 肖承鸿, 谢宇 (2014). 贵州杜仲的生态适宜性区划分析. *中药材*, 37, 760–766.]
- Kang CZ, Zhou T, Guo LP, Huang LQ, Zhu SD, Xiao CH (2016). Ecological suitability and regionalization of *Pseudostellaria heterophylla* (Miq.) Pax ex Pax et Hoffm. in China. *Acta ecologica Sinica*, 36, 2934–2944. [康传志, 周涛, 郭兰萍, 黄璐琦, 朱寿东, 肖承鸿 (2016). 全国栽培太子参生态适宜性区划分析. *生态学报*, 36, 2934–2944.]
- Kang CZ, Zhou T, Jiang WK, Guo LP, Zhang XB, Xiao CH, Zhao D (2016). Quality evaluation and growing regionalization of *Pseudostellaria heterophylla* in Guizhou. *China Journal of Chinese Materia Medica*, 41, 2391–2396. [康传志, 周涛, 江维克, 郭兰萍, 张小波, 肖承鸿, 赵丹 (2016). 贵州栽培太子参质量评价及生长区划. *中国中药杂志*, 41, 2391–2396.]
- Kang CZ, Zhou T, Jiang WK, Guo LP, Zhang XB, Xiao CH, Zhao D (2016). Research on quality regionalization of cultivated *Pseudostellaria heterophylla* based on climate factors. *China Journal of Chinese Materia Medica*, 41, 2386–2390. [康传志, 周涛, 江维克, 郭兰萍, 张小波, 肖承鸿, 赵丹 (2016). 基于气候因子的全国栽培太子参品质区划分析. *中国中药杂志*, 41, 2386–2390.]
- Kou XJ, Li Q, Beierkuhnlein C, Zhao YH, Liu SR (2014). A new tool for exploring climate change induced range shifts of conifer species in China. *PloS One*, 9, e98643.
- Kou XJ, Li Q, Liu SR (2011). Quantifying species' range shifts in relation to climate change: A case study of *Abies* spp. in China. *PloS One*, 6, e23115.
- Lei JC, Xu HG (2010). MaxEnt based prediction of potential distribution of *Solidago canadensis* in China. *Journal of Ecology and Rural Environment*, 26, 137–141. [雷军成, 徐海根 (2010). 基于 MaxEnt 的加拿大一枝黄花在

中国的潜在分布区预测. 生态与农村环境学报, 26, 137–141.]

- Lei JC, Xu HG (2011). Prediction of the potential distribution of the alien invasive plant *Sorghum halepense* in China. *Plant Protection*, 37, 87–92. [雷军成, 徐海根 (2011). 外来入侵植物假高粱在我国的潜在分布区分析. 植物保护, 37, 87–92.]
- Lei JC, Xu HG, Wu J, Guan QW (2015). IPCC AR5-based analysis of variation of potential suitable habitats for evergreen broadleaf forest in China. *Journal of Ecology and Rural Environment*, 31, 69–76. [雷军成, 徐海根, 吴军, 关庆伟 (2015). 基于 IPCC AR5 的我国常绿阔叶林潜在适宜生境变化分析. 生态与农村环境学报, 31, 69–76.]
- Leng WF, He HS, Bu RC, Dai LM, Hu YM, Wang XG (2008). Predicting the distributions of suitable habitat for three larch species under climate warming in Northeastern China. *Forest Ecology Management*, 254, 420–428.
- Leng WF, He HS, Bu RC, Hu YM (2007). Sensitivity analysis of the impacts of climate change on potential distribution of three Larch (*Larix*) species in northeastern. China *Journal of Plant Ecology (Chinese Version)*, 31, 825–833. [冷文芳, 贺红士, 布仁仓, 胡远满 (2007). 中国东北落叶松属 3 种植物潜在分布对气候变化的敏感性分析. 植物生态学报, 31, 825–833.]
- Li A (2016). Study on MaxEnt and ArcGIS to Analyze Potential Suitable Distribution Area of *Pinus Sylvestris* var. *Mongolica* and Its Climatic Suitability--A Case Study of Northeast China. Master dissertation, Shenyang Agricultural University, Shenyang. [李昂 (2016). 应用ArcGIS软件和最大熵模型分析樟子松潜在分布及其气候适宜性--以东北地区为例. 硕士学位论文, 沈阳农业大学, 沈阳.]
- Li C, Liu XA, Wang J, Peng PH, Shao HY (2017). Predictive distribution and habitat suitability assessment of *Taxus chinensis* based on MaxEnt in Sichuan Province. *Journal of Sichuan Forestry Science and Technology*, (5), 1–7+32. [李灿, 刘贤安, 王娟, 彭培好, 邵怀勇 (2017). 基于 MaxEnt 的四川省红豆杉潜在分布区分析及适宜性评价. 四川林业科技, (5), 1–7+32.]
- Li D, Tang XM, Zhu SD, Yang Q, Cheng XX, Zhang CR, Pan LM, Chen DN (2017). Research on distribution and quality suitability division of *Desmodium styracifolium*. *China Journal of Chinese Materia Medica*, 42, 649–656. [李丹, 唐晓敏, 朱寿东, 杨全, 程轩轩, 张春荣, 潘利明, 陈端妮 (2017). 广金钱草分布和品质适宜性区划研究. 中国中药杂志, 42, 649–656.]
- Li F, Zhou GS, Cao MC (2006). Responses of *Larix gmelinii* geographical distribution to future climate change : A simulation study. *Chinese Journal of Applied Ecology*, 17, 2255–2260. [李峰, 周广胜, 曹铭昌 (2006). 兴安落叶松地理分布对气候变化响应的模拟. 应用生态学报, 17, 2255–2260.]
- Li GQ, Du S, Wen ZM (2016). Mapping the climatic suitable habitat of oriental arborvitae (*Platycladus orientalis*) for introduction and cultivation at a global scale. *Scientific Reports*, 6, 30009.
- Li GQ, Liu CC, Liu YG, Yang J, Zhang XS, Guo K (2012). Effects of climate, disturbance and soil factors on the potential distribution of Liaotung oak (*Quercus wutaishanica* Mayr) in China. *Ecological Research*, 27, 427–436.
- Li GQ, Xu GH, Guo K, Du S (2014). Mapping the global potential geographical distribution of black locust (*Robinia pseudoacacia* L.) using herbarium data and a maximum entropy model. *Forests*, 5, 2773–2792.
- Li GQ, Xu GH, Guo K, Du S (2016). Geographical boundary and climatic analysis of *Pinus tabulaeformis* in China: Insights on its afforestation. *Ecological Engineering*, 86, 75–84.
- Li LH, Liu HY, Lin ZS, Jia JH, Liu X (2017). Identifying priority areas for monitoring the invasion of *Solidago canadensis* based on MAXENT and ZONATION. *Acta Ecologica Sinica*, 37, 3124–3132. [李丽鹤, 刘会玉, 林振山, 贾俊鹤, 刘翔 (2017). 基于 MAXENT 和 ZONATION 的加拿大一枝黄花入侵重点监控区确定. 生态学报, 37, 3124–3132.]
- Li RQ, Powers R, Xu M, Zheng YP, Zhao SJ (2018). Proposed biodiversity conservation areas: gap analysis and spatial prioritization on the inadequately studied Qinghai Plateau, China. *Nature Conservation*, 24, 1.
- Li SC, Gao JB (2008). Prediction of spatial distribution of *Eupatorium adenophorum sprengel* based on GARP model : A

- case study in Longitudinal Range—Gorge Region of Yunnan Province. *Chinese Journal of Ecology*, 27, 1531–1536. [李双成, 高江波 (2008). 基于 GARP 模型的紫茎泽兰空间分布预测—以云南纵向岭谷为例. *生态学杂志*, 27, 1531–1536.]
- Li WJ, Peng MC, Higa M, Tanaka N, Matsui T, Tang C Q, Ou XK, Zhou RW, Wang CY, Yan HZ (2016). Effects of climate change on potential habitats of the cold temperate coniferous forest in Yunnan province, southwestern China. *Journal of Mountain Science*, 13, 1411–1422.
- Li XH, Tian HDg, Wang Y, Li RQ, Song ZM, Zhang FC, Xu M, Li DM (2013). Vulnerability of 208 endemic or endangered species in China to the effects of climate change. *Regional Environmental Change*, 13, 843–852.
- Li Y, Yan HF, Ge XJ (2012). Phylogeographic analysis and environmental niche modeling of widespread shrub *Rhododendron simsii* in China reveals multiple glacial refugia during the last glacial maximum. *Journal of Systematics Evolution*, 50, 362–373.
- Li Y, Zhang XW, Fang YM (2014). Predicting the impact of global warming on the geographical distribution pattern of *Quercus variabilis* in China. *Chinese Journal of Applied Ecology*, 25, 3381–3389. [李垚, 张兴旺, 方炎明 (2014). 气候变暖对中国栓皮栎地理分布格局影响的预测. *应用生态学报*, 25, 3381–3389.]
- Li Y, Zhang XW, Fang YM (2016). Responses of the distribution pattern of *Quercus chenii* to climate change following the Last Glacial Maximum. *Chinese Journal of Plant Ecology*, 40, 1164–1178. [李垚, 张兴旺, 方炎明 (2016). 小叶栎分布格局对末次盛冰期以来气候变化的响应. *植物生态学报*, 40, 1164–1178.]
- Liang C, Luo Q, Lu ZZ, Xie ZX, Qin Q, Huang XY (2017). Geographical distribution prediction and key biological climatic factors of *Cymbidium ensifolium* in China based on maximum entropy model and geographic information system. *Northern Horticulture*, (9), 199–204. [梁春, 罗清, 陆祖正, 谢振兴, 覃茜, 黄欣怡 (2017). 基于 Maxent 与 GIS 的我国建兰地理分布预测及关键生物气候因子分析. *北方园艺*, (9), 199–204.]
- Liang T (2013). The Study of GIS Model for Predicting Invasive Species with The Global Climate Change. Master dissertation, Hunan University of Science and Technology, Changsha. [梁田 (2013). 全球气候变化下外来物种入侵GIS预测模型研究. 硕士学位论文, 湖南科技大学, 长沙.]
- Liang W, Min W, Hua OY, Cheng SK, Song MH (2017). Spatial distribution modelling of *Kobresia pygmaea* (Cyperaceae) on the Qinghai-Tibetan Plateau. *Journal of Resources*, 8, 20–30.
- Lin L, Jin L, Cui ZJ, Ma Y (2017). Prediction of the potential distribution of Tibetan medicinal *Lycium ruthenicum* in context of climate change. *China Journal of Chinese Materia Medica*, 42, 2659–2669. [林丽, 晋玲, 王振恒, 崔治家, 马毅 (2017). 气候变化背景下藏药黑果枸杞的潜在适生区分布预测. *中国中药杂志*, 42, 2659–2669.]
- Liu HL, Zhang LW, Zhang HX, Zhang DY, Guan KY (2015). Distribution pattern of species richness for wild fruit trees in Xinjiang based on species distribution modeling. *Scientia Silvae Sinicae*, 51, 1–8. [刘会良, 张玲卫, 张宏祥, 张道远, 管开云 (2015). 基于物种分布模型的新疆野生果树物种丰富度分布格局. *林业科学*, 51, 1–8.]
- Liu JF, Kang FF (2010). Potential impact of climate on istribution of *Cunninghamia lanceolata*. *Journal of southwest Forestry University*, 30, 22–24+32. [刘建锋, 康峰峰 (2010). 杉木潜在适生区及其对气候变化的响应. *西南林业大学学报*, 30, 22–24+32.]
- Liu Q, Wang YK, Peng PH, Lu YF, Chen YF, Wang S (2016). Characteristics of distribution and migration of species in Sichuan under the climate change. *Mountain Research*, 34, 716–723. [刘勤, 王玉宽, 彭培好, 逯亚峰, 陈颖锋, 王跚 (2016). 气候变化下四川省物种的分布规律及迁移特征. *山地学报*, 34, 716–723.]
- Liu QL, Li Y, Fang SZ (2017). Identification of potential cultivation region for *Cyclocarya paliurus* in China based on MaxEnt model. *Journal of Nanjing Forestry University (Natural Sciences Edition)*, 41, 25–29. [刘清亮, 李垚, 方升佐 (2017). 基于 MaxEnt 模型的青钱柳潜在适宜栽培区预测. *南京林业大学学报 (自然科学版)*, 41, 25–29.]
- Liu SJ, Wang B, Li WG, Cai DX, Zhang GF (2017). The prediction on potential climatic suitable region of global natural rubber planting. *Hubei Agricultural Sciences*, 56, 654–656+660. [刘少军, 王斌, 李伟光, 蔡大鑫, 张国

- 峰 (2017). 全球天然橡胶种植的潜在气候适宜区预测. 湖北农业科学, 56, 654–656+660.]
- Liu SJ, Zhou GS, Fang SB (2015). Climatic suitability regionalization of rubber plantation in China. *Scientia Agricultura Sinica*, 48, 2335–2345. [刘少军, 周广胜, 房世波 (2015). 中国橡胶树种植气候适宜性区划. 中国农业科学, 48, 2335–2345.]
- Liu SJ, Zhou GS, Fang SB, Zhang JH (2015). Effects of future climate change on climatic suitability of rubber plantation in China. *Chinese Journal of Applied Ecology*, 26, 2083–2090. [刘少军, 周广胜, 房世波, 张京红 (2015). 未来气候变化对中国天然橡胶种植气候适宜区的影响. 应用生态学报, 26, 2083–2090.]
- Liu W, Zhu L, Sang WG (2007). Potential global geographical distribution of *Amaranthus retroflexus*. *Journal of Plant Ecology (Chinese Version)*, 31, 834–841. [刘伟, 朱丽, 桑卫国 (2007). 影响入侵种反枝苋分布的环境因子分析及可能分布区预测. 植物生态学报, 31, 834–841.]
- Liu X (2012). Prediction of the Invasion Risk for *Alternanthera philoxeroides* in China Based on the GARP and MAXENT Model. Master dissertation, Shandong Normal University, Jinan. [刘欣 (2012). 基于 GARP 和 MAXENT 的空心莲子草在中国的入侵风险预测. 硕士学位论文, 山东师范大学, 济南.]
- Liu X, Liu HY, Gong HB, Lin ZS, Lü SC (2017). Applying the one-class classification method of maxent to detect an invasive plant *Spartina alterniflora* with time-series analysis. *Remote Sensing*, 9, 1120.
- Liu X, Yang YF, Song HP, Zhang XB, Huang LQ, Wu HZ (2016). Cultural regionalization for *Coptis chinensis* based on 3S technology platform I. Study on growth suitability for *Coptis chinensis* based on ecological factors analysis by MaxEnt and ArcGIS model. *China Journal of Chinese Materia Medica*, 41, 3186–3193. [柳鑫, 杨艳芳, 宋红萍, 张小波, 黄璐琦, 吴和珍 (2016). 基于 MaxEnt 和 ArcGIS 的黄连生长适宜性区划研究. 中国中药杂志, 41, 3186–3193.]
- Liu XM, Xing F, Wu M, Zhou HJ, Li HQ (2016). Temporal and spatial propagation of *Alternanthera philoxeroides* in china based on MaxEnt model. *Anhui Agricultural Science Bulletin*, 22, 36–37. [刘晓梅, 邢芬, 武梅, 周红杰, 李宏群 (2016). 基于 Maxent 模型的中国喜旱莲子草时空传播规律研究. 安徽农学通报, 22, 36–37.]
- Liu XY, Li JS, Zhao CY, Quan ZJ, Zhao XJ, Gong L (2016). Prediction of potential suitable area of *Ambrosia artemisiifolia* L. in China based on MAXENT and ArcGIS. *Journal of Plant Protection*, 43, 1041–1048. [柳晓燕, 李俊生, 赵彩云, 全占军, 赵相健, 宫璐 (2016). 基于 MAXENT 模型和 ArcGIS 预测豚草在中国的潜在适生区. 植物保护学报, 43, 1041–1048.]
- Liu Y (2013). Distribution prediction of suitable growth area for *Eucommia ulmoides* in China under climatic change background. *Meteorological Environmental Research*, 4, 21.
- Liu Y (2016). Predictions of suitable distribution of *Meteorium* in China under climate change. *Journal of East China Normal University (Natural Science)*, (6), 192–202. [刘艳 (2016). 气候变化下我国蔓藓属 (*Meteorium*) 适生分布的预测. 华东师范大学学报, (6), 192–202.]
- Liu Y, Atigul M, Sabiram E, Mantimin S (2017). Modeling potential distributions of the desiccation-tolerant moss genus *Schistidium* in Xinjiang under climate change. *Acta Botanica Boreali-Occidentalia Sinica*, 37, 1881–1887. [刘艳, 阿提古丽·毛拉, 沙毕热木·斯热义力, 买买提明·苏来曼 (2017). 气候变化下耐旱藓类连轴藓属在新疆的分布模拟. 西北植物学报, 37, 1881–1887.]
- Liu Y, Zhao ZW (2017). Modeling potential distributions of two wetland moss genera in China under climate change based on a maximum-entropy (Maxent) model. *Chinese Journal of Applied and Environmental Biology*, 23, 792–799. [刘艳, 赵正武 (2017). 基于最大熵模型模拟气候变化下中国两个沼泽藓类属的潜在分布. 应用与环境生物学报, 23, 792–799.]
- Liu YM, Zhou SD, Xie DF, Huang J, He XJ (2018). Potential distribution of *Fritillaria unibracteata* predicted by the MaxEnt model. *Guihaia*, 38, 352–360. [刘艳梅, 周颂东, 谢登峰, 黄娇, 何兴金 (2018). 基于最大熵模型 (MaxEnt) 预测暗紫贝母的潜在分布. 广西植物, 38, 352–360.]
- Liu YT, Dai ZC, Xue YL, Sun JF, Zhu F, Du DL (2013). Prediction of suitable area of an alien invasive species (*Wedelia*

- trilobata) in China. Guangdong Agricultural Sciences, 40, 174–178. [刘勇涛, 戴志聪, 薛永来, 孙见凡, 朱方, 杜道林 (2013). 外来入侵植物南美蟛蜞菊在中国的适生区预测. 广东农业科学, 40, 174–178.]
- Liu ZH, Yang P, Tang HJ, Wu WB, Zhang L, Yu QY, Li ZG (2015). Shifts in the extent and location of rice cropping areas match the climate change pattern in China during 1980–2010. Regional Environmental Change, 15, 919–929.
- Lou YJ, Gao CY, Pan YW, Xue ZS, Liu Y, Tang ZH, Jiang M, Lu XG, Rydin H (2018). Niche modelling of marsh plants based on occurrence and abundance data. Science of the Total Environment, 616, 198–207.
- Lu CY, Gu W, Dai AH, Wei HY (2012). Assessing habitat suitability based on geographic information system (GIS) and fuzzy: A case study of Schisandra sphenanthera Rehd. et Wils. in Qinling Mountains, China. Ecological Modelling, 242, 105–115.
- Lu QX, Zhu JN, Yu D, Xu XW (2016). Genetic and geographical structure of boreal plants in their southern range: phylogeography of Hippuris vulgaris in China. BMC Evolutionary Biology, 16, 34.
- Lu YY, Yang YM, Ma XH, Zhang XB, Zhu SD, Jin L (2016). Ecology suitability study of Chinese materia medica Gentianae macrophyllae radix. China Journal of Chinese Materia Medica, 41, 3176–3180. [卢有媛, 杨燕梅, 马晓辉, 张小波, 朱寿东, 晋玲 (2016). 中药秦艽生态适宜性区划研究. 中国中药杂志, 41, 3176–3180.]
- Lu YY, Zhang XB, Yang YM, Ma XH, Zhu TT, Yu XH, Jin L (2016). Quality regionalization study on Gentianae macrophyllae radix. China Journal of Chinese Materia Medica, 41, 3132–3138. [卢有媛, 张小波, 杨燕梅, 马晓辉, 朱田田, 余晓晖, 晋玲 (2016). 秦艽药材的品质区划研究. 中国中药杂志, 41, 3132–3138.]
- Luo KH, Fu XY, Zhou X (2017). Prediction of the potential geographic diatribution of Taiwanin flousiana inYunnan based on MaxEnt and GIS. Forest Inventory and Planning, 42, 7–10. [罗开华, 付小勇, 周晓 (2017). 基于 MaxEnt 和 GIS 的云南秃杉潜在分布区预测. 林业调查规划, 42, 7–10.]
- Ma BB, Sun J (2018). Predicting the distribution of Stipa purpurea across the Tibetan Plateau via the MaxEnt model. BMC Ecology, 18, 10.
- Ma SM, Nie YB, Duan X, Yu CS, Wang RX (2015). The potential distribution and population protection priority of Amygdalus mongolica. Acta Ecologica Sinica, 35, 2960–2966. [马松梅, 聂迎彬, 段霞, 余存生, 王荣学 (2015). 蒙古扁桃植物的潜在地理分布及居群保护优先性. 生态学报, 35, 2960–2966.]
- Ma SM, Nie YB, Geng QL, Wang RX (2014). Impact of climate change on suitable distribution range and spatial pattern in Amygdalus mongolica. Chinese Journal of Plant Ecology, 38, 262–269. [马松梅, 聂迎彬, 耿庆龙, 王荣学 (2014). 气候变化对蒙古扁桃适宜分布范围和空间格局的影响. 植物生态学报, 38, 262–269.]
- Ma SM, Wei B, Li XC, Luo C, Sun FF (2017). The impacts of climate change on the potential distribution of Haloxylon ammodendron. Chinese Journal of Ecology, 36, 1243–1250. [马松梅, 魏博, 李晓辰, 罗冲, 孙芳芳 (2017). 气候变化对梭梭植物适宜分布的影响. 生态学杂志, 36, 1243–1250.]
- Ma SM, Zhang ML, Chen X (2012). Potential geographical distribution of genus Ammopi ptanthus (Leguminosae) in the eastern central Asian desert and its determinant environmental factors. Journal of Desert Research, 32, 1301–1307. [马松梅, 张明理, 陈曦 (2012). 沙冬青属植物在亚洲中部荒漠区的潜在地理分布及驱动因子分析 中国沙漠, 32, 1301–1307.]
- Ma SM, Zhang ML, Zhang HX, Meng HH, Chen X (2010). Predicting potential geographical distributions and patterns of the relic plant Gymnocarpos przewalskii using Maximum Entropy and Genetic Algorithm for Rule-set Prediction. Chinese Journal of Plant Ecology, 34, 1327–1335. [马松梅, 张明理, 张宏祥, 孟宏虎, 陈曦 (2010). 利用最大熵模型和规则集遗传算法模型预测孑遗植物裸果木的潜在地理分布及格局. 植物生态学报, 34, 1327–1335.]
- Ma XH, Lu YY, Huang DD, Zhu TT, Lü PL, Jin L (2017). Ecology suitability study of Ephedra intermedia. China Journal of Chinese Materia Medica, 42, 2068–2071. [马晓辉, 卢有媛, 黄得栋, 朱田田, 吕培霖, 晋玲 (2017). 中麻黄生态适宜性区划研究. 中国中药杂志, 42, 2068–2071.]

- Ma YH (2013). Applying MaxEnt and ArcGis to Predict Mosses Geographic Distribution Range-A Case Study of Huaping Nature Reserve, Guangxi. Master dissertation, Shanghai Normal University, Shanghai. [麻亚鸿 (2013). 基于最大熵模型 (MaxEnt) 和地理信息系统 (ArcGis) 预测藓类植物的地理分布范围. 硕士学位论文, 上海师范大学, 上海.]
- Maidina T (2017). Studies on Suitable Geographic Distribution of *Xanthium italicum* Moretti in Xinjiang. Master dissertation, Xinjiang University, Wulumuqi. [迈迪娜 吐尔逊 (2017). 意大利苍耳在新疆的适生区分析研究. 硕士学位论文, 新疆大学, 乌鲁木齐.]
- Mao LH, Li Y, Liu C, Fang YM (2017). Predication of potential distribution of *Haplocladium microphyllum* in China based on MaxEnt model. *Chinese Journal of Ecology*, 36, 54–60. [毛俐慧, 李垚, 刘畅, 方炎明 (2017). 基于 MaxEnt 模型预测细叶小羽藓在中国的潜在分布区. *生态学杂志*, 36, 54–60.]
- Mao ZY, Zhang ZJ, Zhou J (2014). The prediction on potential geographic distribution of *Lycoris radiata* based on ecological niche models. *China Forestry Science and Technology*, 28, 50–53. [毛志远, 张兆金, 周坚 (2014). 基于生态位模型的石蒜适生区预测. *林业科技开发*, 28, 50–53.]
- Mi CR, Zu Q, He L, Huettmann F, Jin N, Li J (2017). Climate change would enlarge suitable planting areas of sugarcane in China. *International Journal of Plant Production*, 11, 151–166.
- Miao Q, Yuan YJ, Luo GM, Wei CH, Rao YQ, Gong YH, Zhang L, Shao J, Dong YK (2016). Study on ecological suitability of *Gardenia jasminoides* based on ArcGIS and Maxent model. *China Journal of Chinese Materia Medica*, 41, 3181–3185. [苗琦, 袁源见, 罗光明, 魏春华, 饶雅琪, 龚雨虹, 张兰, 邵坚, 董艳凯 (2016). 基于 ArcGIS 和 Maxent 的栀子生态适宜性研究. *中国中药杂志*, 41, 3181–3185.]
- Mu J (2013). Predicting and Mapping the Potential Spatial Distribution of *Chamaecyparis Formosensis* in Central Taiwan with Species Distribution Models. Master dissertation, Beijing Forestry University, Beijing. [穆婧 (2013). 物种分布模型模拟绘制红桧于台湾中部适生地范围. 硕士学位论文, 北京林业大学, 北京.]
- Niu YT, Ye JF, Zhang JL, Wan JZ, Yang T, Wei XX, Lu LM, Li JH, Chen ZD (2018). Long - distance dispersal or postglacial contraction? Insights into disjunction between Himalaya–Hengduan Mountains and Taiwan in a cold - adapted herbaceous genus, *Triplostegia*. *Ecology Evolution*, 8, 1131–1146.
- Pan YS, Zhu ZH, Yao TH, Wang YX, Zhou P (2016). Predicting suitable habitats of medicinal plant *Fallopia multiflora* in China under climate change scenarios. *Journal of Northwest A&F University (Natural Science Edition)*, 44, 192–198. [潘石玉, 朱志红, 姚天华, 王彦星, 周佩 (2016). 气候变化背景下药用植物何首乌在中国适生区分布预测. *西北农林科技大学学报 (自然科学版)*, 44, 192–198.]
- Peng LX, Guo YL (2017). Geographical distribution of *Astragali radix* and prediction of its suitable area in China. *Journal of Sichuan Agricultural University*, 35, 60–68. [彭露茜, 郭彦龙 (2017). 中国黄芪地理分布和未来适生区预测. *四川农业大学学报*, 35, 60–68.]
- Peng SZ, Zhao CY, Xu ZL, Ashiq M W (2016). Restoration and conservation potential of destroyed Qinghai spruce (*Picea crassifolia*) forests in the Qilian Mountains of northwest China. *Mitigation Adaptation Strategies for Global Change*, 21, 153–165.
- Peng SZ, Zhao CY, Xu ZL, Wang C, Liu YY (2011). Potential distribution of Qinghai spruce and assessment of its growth status in the upper reaches of the Heihe River in the Qilian Mountains of China. *Chinese Journal of Plant Ecology*, 35, 605–614. [彭守璋, 赵传燕, 许仲林, 王超, 柳逸月 (2011). 黑河上游祁连山区青海云杉生长状况及其潜在分布区的模拟. *植物生态学报*, 35, 605–614.]
- Peng Y, Wang Y, Gu H, Ye JR (2016). Prediction of potential geographic distribution of alien species *Coreopsis grandiflora* in China. *Journal of Nanjing Forestry University (Natural Sciences)*. [彭冶, 王焱, 顾慧, 叶建仁 (2016). 外来观赏植物大花金鸡菊在中国的潜在地理分布预测. *南京林业大学学报 (自然科学版)*, 40, 53–58.]
- Qi XS, Chen C, Comes H P, Sakaguchi S, Liu YH, Tanaka N, Sakio H, Qiu YX (2012). Molecular data and ecological

- niche modelling reveal a highly dynamic evolutionary history of the East Asian Tertiary relict *Cercidiphyllum* (*Cercidiphyllaceae*). *New Phytologist*, 196, 617–630.
- Qin AL, Liu B, Guo QS, Bussmann R W, Ma FQ, Jian ZJ, Xu GX, Pei SX (2017). Maxent modeling for predicting impacts of climate change on the potential distribution of *Thuja sutchuenensis* Franch., an extremely endangered conifer from southwestern China. *Global Ecology Conservation*, 10, 139–146.
- Qin XW, Hao CY, Li FP, Tan LH, Song YH, Lai JX (2016). Potential distribution of *Theobroma cacao* L. using maximum entropy. *Chinese Journal of Tropical Crops*, 37, 1022–1029. [秦晓威, 郝朝运, 李付鹏, 谭乐和, 宋应辉, 赖剑雄 (2016). 基于 MaxEnt 模型的可可潜在适宜分布研究. *热带作物学报*, 37, 1022–1029.]
- Qin Z, DiTommaso A, Wu RS, Huang HY (2014). Potential distribution of two *Ambrosia* species in China under projected climate change. *Weed Research*, 54, 520–531.
- Qin Z, Zhang JE, Jiang YP, Wei H, Wang FG, Lu XN (2018). Invasion process and potential spread of *Amaranthus retroflexus* in China. *Weed Research*, 58, 57–67.
- Qu H, Wang CJ, Zhang ZX (2018). Planning priority conservation areas under climate change for six plant species with extremely small populations in China. *Nature Conservation*, 25, 89–106.
- Qu ZJ, Zhou GS (2016). Climate suitability for potential Fuji apple cultivation in China. *Acta Meteorologica Sinica*, 4, 479–490. [屈振江, 周广胜 (2016). 中国富士苹果种植的气候适宜性研究. *气象学报*, 4, 479–490.]
- Qu ZJ, Zhou GS (2017). Regionalization of climatic suitability for major kiwifruit cultivars in China. *Chinese Journal of Agrometeorology*, 38, 257–266. [屈振江, 周广胜 (2017). 中国主栽猕猴桃品种的气候适宜性区划. *中国农业气象*, 38, 257–266.]
- Ranjitkar S, Kindt R, Sujakhu N M, Hart R, Guo W, Yang XF, Shrestha KK, Xu JC, Luedeling E (2014). Separation of the bioclimatic spaces of Himalayan tree rhododendron species predicted by ensemble suitability models. *Global Ecology Conservation*, 1, 2–12.
- Ranjitkar S, Sujakhu N M, Lu Y, Wang Q, Wang MC, He J, Mortimer P E, Xu JC, Kindt R, Zomer R (2016). Climate modelling for agroforestry species selection in Yunnan Province, China. *Environmental Modelling Software*, 75, 263–272.
- Sang MJ (2015). Influence and Evaluation of Environmental Variables on Species Distribution Model, Using *Cornus officinalis* Sieb. et Zucc. as an Sample. Master dissertation, Shaanxi Normal University, Xi'an. [桑满杰 (2015). 环境变量对物种分布模型的影响与评价——山茱萸潜在地理分布预测为例. 硕士学位论文, 陕西师范大学, 西安.]
- Shao H, Tian JQ, Guo K, Sun JX (2009). Effects of sample size and species traits on performance of BIOCLIM in predicting geographical distribution of tree species-A case study with 12 deciduous *Quercus* species indigenous to China. *Chinese Journal of Plant Ecology*, 33, 870–877. [邵慧, 田佳倩, 郭柯, 孙建新 (2009). 样本容量和物种特征对 BIOCLIM 模型模拟物种分布准确度的影响——以 12 个中国特有落叶栎树种为例. *植物生态学报*, 33, 870–877.]
- Shao Y, Ye D, Ouyang Z, Huang LQ, Peng HS, Zhang XB, Zhu SD, Yu YF, Jiang FR (2016). Habitat suitability and quality division of *Mentha haplocalyx*. *China Journal of Chinese Materia Medica*, 41, 3169–3175. [邵扬, 叶丹, 欧阳臻, 黄璐琦, 彭华胜, 张小波, 朱寿东, 于一凡, 蒋芳蓉 (2016). 薄荷的生境适宜性区划及品质区划研究. *中国中药杂志*, 41, 3169–3175.]
- Shao YL, Cao W (2017). Prediction of the potential distribution area of invasive alien plant *Ambrosia artemisiifolia* in Northeast China. *Journal of Arid Land Resources and Environment*, 31, 172–176. [邵云玲, 曹伟 (2017). 外来入侵植物豚草在中国东北潜在分布区预测. *干旱区资源与环境*, 31, 172–176.]
- Shao YZ, Zhang XC, Phan L K, Xiang QP (2017). Elevation shift in *Abies* Mill.(Pinaceae) of subtropical and temperate China and Vietnam—Corroborative evidence from cytoplasmic DNA and ecological niche modeling. *Frontiers in Plant Science*, 8, 578.

- Shen T, Zhang J, Shen SK, Zhao YL, Wang YZ (2017). Distribution simulation of *Gentiana rhodantha* in Southwest China and assessment of climate change impact. *Chinese Journal of Applied Ecology*, 28, 2499–2508. [沈涛, 张霁, 申仕康, 赵艳丽, 王元忠 (2017). 西南地区红花龙胆分布格局模拟与气候变化影响评价. *应用生态学报*, 28, 2499–2508.]
- Shen Y, Yu J, Guo SL (2015). *Macromitrium* and *Orthotrichum* distribution patterns under different climate warming scenarios in China. *Acta Ecologica Sinica*, 35, 6449–6459. [沈阳, 于晶, 郭水良 (2015). 不同气候变化情境下中国木灵藓属和藓属植物的潜在分布格局. *生态学报*, 35, 6449–6459.]
- Shen ZH, Fang JY, Chiu CG, Chen TY (2015). The geographical distribution and differentiation of Chinese beech forests and the association with *Quercus*. *Applied Vegetation Science*, 18, 23–33.
- Shi W (2012). Study impact of non-climate factors on production for *Stipa* communities in Inner Mongolia Plateau with the help of maximum entropy principle. *Guangdong Agricultural Sciences*, (22), 184–186. [石慰 (2012). 非气候因素对草原植物生产力影响的最大熵研究. *广东农业科学*, (22), 184–186.]
- Shi W (2014). Effects of Climate Change on Distribution of *Larix Gmelinii* in Northeast China. Master dissertation, Beijing Forestry University, Beijing. [石慰 (2014). 气候变化对中国东北兴安落叶松分布的影响. 硕士学位论文, 北京林业大学, 北京.]
- Shi W, Tong H (2013). Prediction of potential distribution of Chinese fir in Guizhou next 70 years and ecological countermeasures. *Journal of Central South University of Forestry & Technology*, 33, 87–92. [石慰, 童红 (2013). 未来七十年贵州杉木林潜在适生区的变化及其生态对策. *中南林业科技大学学报*, 33, 87–92.]
- Shi ZW, Kang LP, Peng HS, Yang SH, Zhang LX, Jiang ZX, Chen M, Liu DH (2017). Climate suitability for potential *Pairs polyphylla* var. *yunnanensis* cultivation in China. *China Journal of Chinese Materia Medica*, 42, 3435–3442. [石子为, 康利平, 彭华胜, 杨少华, 张丽霞, 景志贤, 陈敏, 刘大会 (2017). 我国滇重楼种植的气候适宜性研究. *中国中药杂志*, 42, 3435–3442.]
- Shi ZW, Ma CJ, Kang CZ, Wang L, Zhang ZH, Chen JF, Zhang XB, Liu DH (2016). Ecological suitability regionalization for *Gastrodia elata* in Zhaotong based on Maxent and ArcGIS. *China Journal of Chinese Materia Medica*, 41, 3155–3163. [石子为, 马聪吉, 康传志, 王丽, 张智慧, 陈骏飞, 张小波, 刘大会 (2016). 基于空间分析的昭通天麻生态适宜性区划研究. *中国中药杂志*, 41, 3155–3163.]
- Si SB (2012). The Plant Analyse of Typical Pots in Nanling Mountain and the Determination Research of *Rhodomyrtus Tomentosa*. Master dissertation, Central South University of Forestry and Technology, Changsha. [司书斌 (2012). 南岭典型样地植物分析及桃金娘分布研究. 硕士学位论文, 中南林业科技大学, 长沙.]
- Song SS (2015). Preliminary Study on Diversity and Distribution of Pottiaceae in Arid ang Semiarid Area of Tibet, China. Doctor dissertation, China Agricultural University, Beijing. [宋闪闪 (2015). 西藏干旱半干旱区丛藓科物种多样性及空间分布的初步研究. 博士学位论文, 中国农业大学, 北京.]
- Su XH, Tang XY, Gu XJ, Wang WG, He MX, Hu QC (2013). Wetland plant screening based on the purification effect and climate adaptability. *Environmental Pollution & Control*, 35, 54–58. [苏小红, 汤晓玉, 顾新娇, 王文国, 何明雄, 胡启春 (2013). 基于去污效果和气候适应性的湿地植物筛选研究. *环境污染与防治*, 35, 54–58.]
- Su ZH, Pan BR, Zhuo L, Li WJ, Liu HL, Jiang XL, Yan DM (2018). Impact of future climate change on distribution pattern of *Tamarix taklamakanensis* and its conservation revelation. *Arid Zone Research*, 35, 150–155. [苏志豪, 潘伯荣, 卓立, 李文军, 刘会良, 姜小龙, 闫德民 (2018). 未来气候变化对特有物种沙生怪柳分布格局的影响及其保护启示. *干旱区研究*, 35, 150–155.]
- Sun B, Lou YX, Guo SL (2014). On climatic adaptability of cultivating wild vegetable *Cryptotaenia japonica* in China. *Acta Agriculturae Shanghai*, 30, 85–89. [孙兵, 娄玉霞, 郭水良 (2014). 野生蔬菜鸭儿芹在中国栽培的气候适应性研究. *上海农业学报*, 30, 85–89.]
- Sun HB, Sun H, Jiang SY, Zhou Y, Cao WL, Ji MC, Zhu WT, Yan JH (2015). Cultural regionalization for *Notopterygium incisum* based on 3S technology platform I. Evaluation for growth suitability for *N. incisum* based on ecological

- factors analysis by MaxEnt and ArcGIS model. *China Journal of Chinese Materia Medica*, 30, 853. [孙洪兵, 孙辉, 蒋舜媛, 周毅, 曹文龙, 纪明昌, 朱文涛, 严寒静 (2015). 基于 3S 技术的羌活区划研究 I. 基于 MaxEnt 和 ArcGIS 的羌活生长适宜性分析及评价. *中国中药杂志*, 30, 853.]
- Sun JS, Zhou GS (2012). Inter-decadal variability of winter wheat planting zone in China during 1961 to 2010 simulated by maximum entropy (MaxEnt). *Chinese Journal of Agrometeorology*, 33, 481–487. [孙敬松, 周广胜 (2012). 利用最大熵法 (MaxEnt) 模拟中国冬小麦分布区的年代际动态变. *中国农业气象*, 33, 481–487.]
- Sun RX (2017). Genetic Diversity and Phylogeography of *Liquidambar Formosana* Hance in China. Doctor dissertation, Chinese Academy of Forestry, Beijing. [孙荣喜 (2017). 中国枫香树遗传多样性及谱系地理研究. 博士学位论文, 中国林业科学研究院, 北京.]
- Tan JN, Li Q, Bai S, Wang JX (2016). Prediction of potential distribution of Japanese Brome (*Bromus japonicus*) based on MaxEnt. *Chinese Agricultural Science Bulletin*, 32, 49–54. [谭金妮, 李琦, 白霜, 王金信 (2016). 基于 MaxEnt 的农田恶性杂草雀麦的潜在分布预测. *中国农学通报*, 32, 49–54.]
- Tan ZT (2014). Research Ecological Suitability Regionalization of *Atractylodes macrocephala*. Master dissertation, Hebei Medical University, Shijiazhuang. [谭喆天 (2014). 白术生态适宜性区划研究. 硕士学位论文, 河北医科大学, 石家庄.]
- Tang C Q, Dong YF, Herrando-Moraira S, Matsui T, Ohashi H, He LY, Nakao K, Tanaka N, Tomita M, Li XS (2017). Potential effects of climate change on geographic distribution of the Tertiary relict tree species *Davidia involucrata* in China. *Scientific Reports*, 7, 43822.
- Tang C, Wen J, Zhang W, Su JS, Xie CX, Zhang Y (2017). Potential distribution of the traditional Tibetan herb *Pterocephalus hookeri* by Maxent model. *China Journal of Chinese Materia Medica*, 42, 1871–1876. [唐策, 文检, 张雯, 苏锦松, 谢彩香, 张艺 (2017). 基于最大熵模型的藏药翼首草生态适宜性研究. *中国中药杂志*, 42, 1871–1876.]
- Tang XQ, Li JL (2016). Impact analysis on distribution prediction of *Stipa* species under climate change. *Journal of System Simulation*, 28, 956–965. [唐旭清, 李建林 (2016). 气候变化对多针茅竞争分布预测与影响分析. *系统仿真学报*, 28, 956–965.]
- Tang Y, Winkler JA, Vi ña A, Liu JG, Zhang YB, Zhang XF, Li XH, Wang F, Zhang JD, Zhao ZQ (2018). Uncertainty of future projections of species distributions in mountainous regions. *PloS One*, 13, e0189496.
- Tian JQ (2007). Differentiated Distribution of Deciduous *Quercus* Spp. and Ontrolling Climatic Factors in China. Master dissertation, Institute of Botany, Chinese Academy of Science, Beijing. [田佳倩 (2007). 落叶栎树在中国的地理替代分布及其气候制约. 硕士学位论文, 中国科学院植物研究所, 北京.]
- Tian ZS, Xu L, Cheng DD (2016). Prediction of the potential distribution of *Senecio jacobaea* in China. *Journal of Biosafety*, 25, 114–122. [田忠赛, 徐琳, 程丹丹 (2016). 新疆千里光 *Senecio jacobaea* 在中国的适生区预测. *生物安全学报*, 25, 114–122.]
- Wan JZ, Wang CJ, Yu JH, Nie SM, Han SJ, Wang LH, Liu JZ, Zu YG (2015). Model-based assessment of priority protected areas: A case study on *Fraxinus mandshurica* in China. *Polish Journal of Environmental Studies*, 24, 725–733.
- Wan JZ, Wang CJ, Han SJ, Yu JH (2014). Application of GIS and Maxent to predict the potential geographical distribution of *Taxus chinensis* var. *mairei* and the protection suggestions. *Jiangsu Agricultural Sciences*, 42, 349–352. [万基中, 王春晶, 韩士杰, 于景华 (2014). 应用 GIS 和 Maxent 预测南方红豆杉潜在地理分布及其保护建议. *江苏农业科学*, 42, 349–352.]
- Wan JZ, Wang CJ, Han SJ, Yu JH (2014). Planning the priority protected areas of endangered orchid species in northeastern China. *Biodiversity Conservation*, 23, 1395–1409.
- Wan JZ, Wang CJ, Han SJ, Yu JH (2014). The planning of priority protection area for *Taxus cuspidata* under climate change. *Journal of Shenyang Agricultural University*, 45, 28–32. [万基中, 王春晶, 韩士杰, 于景华 (2014). 气

候变化压力下建立东北红豆杉优先保护区的模拟规划. 沈阳农业大学学报, 45, 28–32.]

- Wan JZ, Wang CJ, Tan JF, Yu FH (2017). Climatic niche divergence and habitat suitability of eight alien invasive weeds in China under climate change. *Ecology Evolution*, 7, 1541–1552.
- Wan JZ, Wang CJ, Yu FH (2017). Modeling impacts of human footprint and soil variability on the potential distribution of invasive plant species in different biomes. *Acta Oecologica*, 85, 141–149.
- Wan JZ, Wang CJ, Yu FH (2017). Spatial conservation prioritization for dominant tree species of Chinese forest communities under climate change. *Climatic Change*, 144, 303–316.
- Wan JZ, Wang CJ, Yu JH, Han SJ, Wang LH, Wang QG (2014). The ability of Nature Reserves to conserve medicinal plant resources: A case study in northeast China. *Ecological Informatics*, 24, 27–34.
- Wan JZ, Wang CJ, Yu JH, Nie SM, Han SJ, Liu JZ, Zu YG, Wang QH (2016). Developing conservation strategies for *Pinus koraiensis* and *Eleutherococcus senticosus* by using model-based geographic distributions. *Journal of Forestry Research*, 27, 389–400.
- Wan JZ, Wang CJ, Yu JH, Nie SM, Han SJ, Zu YG, Chen CM, Yuan SS, Wang QG (2014). Model-based conservation planning of the genetic diversity of *Phellodendron amurense* Rupr due to climate change. *Ecology Evolution*, 4, 2884–2900.
- Wang C, Lin HL, Feng QS, Jin CY, Cao AC, He L (2017). A new strategy for the prevention and control of *Eupatorium adenophorum* under climate change in China. *Sustainability*, 9, 2037.
- Wang C, Lin HL, He L, Cao AC (2014). Research on responses of *Eupatorium adenophorum*'s potential distribution to climate change. *Acta Prataculturae Sinica*, 23, 20–30. [王翀, 林慧龙, 何兰, 曹勘程 (2014). 紫茎泽兰潜在分布对气候变化响应的研究. 草业学报, 23, 20–30.]
- Wang CJ, Wan JZ, Mu XY, Zhang ZX (2015). Management planning for endangered plant species in priority protected areas. *Biodiversity Conservation*, 24, 2383–2397.
- Wang CJ, Wan JZ, Zhang GM, Zhang ZX, Zhang J (2016). Protected areas may not effectively support conservation of endangered forest plants under climate change. *Environmental Earth Sciences*, 75, 466.
- Wang CJ, Wan JZ, Zhang ZX, Zhang GM (2016). Identifying appropriate protected areas for endangered fern species under climate change. *SpringerPlus*, 5, 904.
- Wang CJ, Wan JZ, Zhang ZX, Zhao LC (2017). Integrating climate change into conservation planning for *Taxus chinensis*, an endangered endemic tree plant in China. *Journal of Animal Plant Sciences*, 27, 219–226.
- Wang D, Wei HY, Yang Y, Shang ZH, Gu WN (2017). MaxEnt and GIS modeling for predicting the potential distribution of *Bupleurum marginatum*. *Journal of Chinese Medicinal Material*, 40, 301–305. [王丹, 卫海燕, 杨洋, 尚忠慧, 顾蔚 (2017). 基于 MaxEnt 和 GIS 的竹叶柴胡适生区分布预测. 中药材, 40, 301–305.]
- Wang G (2013). Modelling the Geographic Distribution and Study on the ISSR Genetic Diversity of *Rhododendron maculiferum*. Master dissertation, Anhui Agricultural University, Hefei. [王刚 (2013). 黄山杜鹃地理分布模拟及 ISSR 遗传多样性研究. 硕士学位论文, 安徽农业大学, 合肥.]
- Wang G, Meng YQ, Sun J, Wang LH, Yan SF, Cheng YH (2013). Modeling the geographic distribution of *Rhododendron maculiferum*. *Journal of Northwest A&F University (Natural Science Edition)*, 41, 173–177. [王刚, 孟艳琼, 孙婧, 王雷宏, 闫士凤, 程耀辉 (2013). 麻花杜鹃的地理分布模拟. 西北农林科技大学学报, 41, 173–177.]
- Wang HQ, Wang Q, Ma L, Ding R, Di TY, An W, Zhang XB, Wang YH (2016). Production regionalization study of *Lycii fructus*. *China Journal of Chinese Materia Medica*, 41, 3127–3131. [王汉卿, 王庆, 马玲, 丁锐, 狄天云, 安巍, 张小波, 王英华 (2016). 枸杞子药材生产区划研究. 中国中药杂志, 41, 3127–3131.]
- Wang J (2007). Simulation of Distribution and Assessment of Climate Change Impact on Five *Caragana* and Seven *Stipa* Species in Temperate Northern China. Master dissertation, Institute of Botany, Chinese Academy of Sciences, Beijing. [王娟 (2007). 中国北方温带地区针茅和锦鸡儿属植物的分布格局模拟. 硕士学位论文, 中国科学]

院植物研究所, 北京.]

- Wang J, Ni J (2009). Modelling the distribution of five *Caragana* in temperate northern China. *Chinese Journal of Plant Ecology*, 33, 12–24. [王娟, 倪健 (2009). 中国北方温带地区 5 种锦鸡儿植物的分布模拟. *植物生态学报*, 33, 12–24.]
- Wang JJ, Cao B, Bai CK, Zhang LL, Che L (2014). Potential distribution prediction and suitability evaluation of *Fritillaria cirrhosa* D. Don based on Maxent modeling and GIS. *Bulletin of Botanical Research*, 34, 642–649. [王娟娟, 曹博, 白成科, 张琳琳, 车乐 (2014). 基于 Maxent 和 ArcGIS 预测川贝母潜在分布及适宜性评价. *植物研究*, 34, 642–649.]
- Wang LH, Yang JX, Huang CL (2013). Modelling geographic distribution of *Malus hupehensis* with MaxEnt. *Journal of Anhui Agricultural University*, 40, 383–386. [王雷宏, 杨俊仙, 黄成林 (2013). 用 MaxEnt 模拟湖北海棠 (*Malus hupehensis*) 地理分布. *安徽农业大学学报自然版*, 40, 383–386.]
- Wang LH, Yang JX, Xu XN (2015). Analysis of suitable bioclimatic characteristics of *Pseudolarix amabilis* by using MaxEnt model. *Scientia Silvae Sinicae*, 51, 127–131. [王雷宏, 杨俊仙, 徐小牛 (2015). 基于 MaxEnt 分析金钱松适生的生物气候特征. *林业科学*, 51, 127–131.]
- Wang P (2017). Studies on Genetic Diversity and Phylogeography of *Libanotis buchtormensis*. Master dissertation, Northwest A&F University, Yangling. [王平 (2017). 岩风的遗传多样性与谱系地理学研究. 硕士学位论文, 西北农林科技大学, 杨凌.]
- Wang Q, Guo SL (2016). Climate adaptability of *Rhodobryum giganteum* and its potential geographic distribution in China. *Journal of Hangzhou Normal University (Natural Science Edition)*, 15, 368–376. [王强, 郭水良 (2016). 暖地大叶藓的气候适应性及其在中国的潜在分布区预测. *杭州师范大学学报*, 15, 368–376.]
- Wang Q, Yang L, Ranjitkar S, Wang JJ, Wang XR, Zhang DX, Wang ZY, Huang YZ, Zhou YM, Deng ZX (2017). Distribution and in situ conservation of a relic Chinese oil woody species *Xanthoceras sorbifolium* (yellowhorn). *Canadian Journal of Forest Research*, 47, 1450–1456.
- Wang R, Wan FH (2010). Prediction of the potential survival area of *Xanthium italicum* in China. *Acta Prataculturae Sinica*, 19, 222–230. [王瑞, 万方浩 (2010). 外来入侵植物意大利苍耳在我国适生区预测. *草业学报*, 19, 222–230.]
- Wang R, Wan FH (2016). Predicting the potential invasive distribution and early-warning monitoring management of *Solanum elaeagnifolium* in China. *Chinese Journal of Ecology*, 35, 1697–1703. [王瑞, 万方浩 (2016). 入侵植物银毛龙葵在中国的适生区预测与早期监测预警. *生态学杂志*, 35, 1697–1703.]
- Wang R, Wang YZ (2006). Invasion dynamics and potential spread of the invasive alien plant species *Ageratina adenophora* (Asteraceae) in China. *Diversity Distributions*, 12, 397–408.
- Wang R, Xian XQ, Wan FH (2016). Predicting the potential invasive distribution of *Solanum carolinense* in China. *China Journal of Chinese Materia Medica*, 25, 106–113. [王瑞, 冼晓青, 万方浩 (2016). 北美刺龙葵在中国的适生区预测. *生物安全学报*, 25, 106–113.]
- Wang SY, Xu XT, Shrestha N, Zimmermann NE, Tang ZY, Wang ZH (2017). Response of spatial vegetation distribution in China to climate changes since the Last Glacial Maximum (LGM). *PloS One*, 12, e0175742.
- Wang TL, Wang GY, Innes J, Nitschke C, Kang HJ (2016). Climatic niche models and their consensus projections for future climates for four major forest tree species in the Asia-Pacific region. *Forest Ecology Management*, 360, 357–366.
- Wang W, Tian CY, Li YH, Li Y (2014). Molecular data and ecological niche modelling reveal the phylogeographic pattern of *Cotinus coggygia* (Anacardiaceae) in China's warm-temperate zone. *Plant Biology*, 16, 1114–1120.
- Wang W, Tian RR, Na LY, Yang Y, Xu XQ (2017). Predicting potential geographic suitable regions of *Macadamia integrifolia* based on MaxEnt. *Forest Research*, 30, 444–449. [王伟, 田荣荣, 那立妍, 杨颖, 许新桥 (2017). 基于 MaxEnt 生态软件划分澳洲坚果的潜在地理适生区. *林业科学研究*, 30, 444–449.]

- Wang WG, Li R, Wang SH, Chen F (2010). GIS-Based analysis on suitable distribution area and habitat of *Pogonatherum paniceum*, a plant for soil and water conservation. *Soil and Water Conservation in China*, (6), 33–35. [王文国, 李锐, 王胜华, 陈放 (2010). 基于 GIS 的水土保持植物金发草的适生区与生境分析. *中国水土保持*, (6), 33–35.]
- Wang WG, Tang XY, Zhu QL, Pan K, Hu QC, He MX, Li JT (2014). Predicting the impacts of climate change on the potential distribution of major native non-food bioenergy plants in China. *PloS One*, 9, e111587.
- Wang WG, Zu XH, Tang XY, Hou YQ, Hu QC (2013). Environmental risk assessment and management of exotic wetland plants used for treatment of rural domestic. *Journal of Ecology and Rural Environment*, 29, 191–196. [王文国, 苏小红, 汤晓玉, 侯远青, 胡启春 (2013). 用于农村生活污水处理的常见外来湿地植物的环境风险评估与管理. *生态与农村环境学报*, 29, 191–196.]
- Wang XL, Su CJ, Peng L, Wang HE, Wang HM, Liu W, Li P, Fang Y (2014). Ecological suitability assessment and introduction experiment on *Rosa damascena trigintipetala* in Sichuan Province, China. *Journal of Mountain Science*, 11, 805–815.
- Wang YH, Jiang WM, Comes H P, Hu FS, Qiu YX, Fu CX (2015). Molecular phylogeography and ecological niche modelling of a widespread herbaceous climber, *Tetrastigma hemsleyanum* (Vitaceae): insights into Plio-Pleistocene range dynamics of evergreen forest in subtropical China. *New Phytologist*, 206, 852–867.
- Wang YL, Li H, Yang X, Guo YL, Li WD (2017). Prediction of geographical distribution of *Vitex trifolia* var. *simplicifolia* under climate change based on the MaxEnt model. *Acta Prataculturae Sinica*, 26, 1–10. [王亚领, 李浩, 杨旋, 郭彦龙, 李维德 (2017). 基于 MaxEnt 模型和不同气候变化情景的单叶蔓荆潜在地理分布预测. *草业学报*, 26, 1–10.]
- Wang YQ, Wei YK, Huang YB (2015). Research on distribution pattern of Subg. *Salvia* Benth. (Lamiaceae), an important group of medicinal plants in East Asia. *Acta Ecologica Sinica*, 35, 1470–1479. [王摇琦, 魏宇昆, 黄艳波 (2015). 中国弧隔鼠尾草亚属 (唇形科) 的分布格局. *生态学报*, 35, 1470–1479.]
- Wang Z, Li B, Xiao JL, Jiang DC (2017). Regionalization study of *Dioscorea nipponica* in Jilin province based on MaxEnt and GIS. *China Journal of Chinese Materia Medica*, 42, 4373–4377. [王哲, 李波, 肖井雷, 姜大成 (2017). 基于 MaxEnt 和 ArcGIS 的吉林省穿龙薯蓣分布区划研究. *中国中药杂志*, 42, 4373–4377.]
- Wei XZ, Sork V L, Meng HJ, Jiang MX (2016). Genetic evidence for central-marginal hypothesis in a Cenozoic relict tree species across its distribution in China. *Journal of biogeography*, 43, 2173–2185.
- Wen J, Lü XM, Hong DX, Xie CX, Zhang J, Zhang Y (2016). Potential distribution of *Rhodiola crenulata* in Tibetan Plateau based on Maxent model. *China Journal of Chinese Materia Medica*, 41, 3931–3936. [文检, 吕秀梅, 洪道鑫, 谢彩香, 张静, 张艺 (2016). 基于 Maxent 模型的青藏高原大花红景天生态适宜性分析. *中国中药杂志*, 41, 3931–3936.]
- Wen J, Song JY, Xie CX, Zhang Q, Zeng FL, Zhang Y (2016). Identification of potential distribution areas for energy plant *Jatropha curcas* L. using the Maxent Entropy Model. *Plant Science Journal*, 34, 849–856. [文检, 宋经元, 谢彩香, 张琴, 曾凡琳, 张艺 (2016). 基于最大信息熵模型的能源物种麻疯树潜在适宜区. *植物科学学报*, 34, 849–856.]
- Wen ZB, Zhang J, Zhang ML (2016). Geographical distribution and prediction on potential distribution areas of Chinese endemic species *Salsola junatovii*. *Journal of Plant Resources and Environmen*, (1), 81–87. [闻志彬, 张杰, 张明理 (2016). 中国特有种天山猪毛菜的地理分布及潜在分布区预测. *植物资源与环境学报*, (1), 81–87.]
- Wen ZM, He XH, Jiao F, Jiao JY (2007). Distribution prediction of *Stipa bungeana* Trin. in Yanhe river basin-generalized additive model and its application. In: *Seminar of National Soil and Water Conservation and Ecological Environment Restoration and Construction*, Wulumuqi, 55–63. [温仲明, 赫晓慧, 焦峰, 焦菊英 (2007). [延河流域长芒草分布预测—广义相加模型及其应用. 全国水土保持及生态环境恢复建设交流研讨会, 乌鲁木齐. 55–63.]

- Wen ZM, He XH, Jiao F, Jiao JY (2008). The predictive distribution of *Stipa bungeana* in Yunnan River catchment: GAM model and its application. *Acta Ecologica Sinica*, 28, 192–201. [温仲明, 赫晓慧, 焦峰, 焦菊英 (2008). 延河流域本氏针茅 (*Stipa bungeana*) 分布预测—广义相加模型及其应用. *生态学报*, 28, 192–201.]
- Wu JG (2011). The potential effects of climate change on the distributions of 7 plants in China. *Guihaia*, 31, 595–607. [吴建国 (2011). 气候变化对我国 7 种植物潜在分布的影响. *广西植物*, 31, 595–607.]
- Wu MY, He L, Chen JL, Dong G, Cheng WX (2017). Predictive distribution and planting GAP of *Cyathula officinalis* in China based on 3S technology and MaxEnt modelling. *China Journal of Chinese Materia Medica*, 42, 4395–4401. [巫明焱, 何兰, 陈佳丽, 董光, 程武学 (2017). 基于 3S 技术和 MaxEnt 的川牛膝在中国的潜在分布及种植空缺分析. *中国中药杂志*, 42, 4395–4401.]
- Wu WQ, Wen NL, Xiao Y, Zhong RZ, Ru ZZ (2017). Geographic distribution and potential distribution estimation of *Machilus breviflora*. *Guangdong Agricultural Sciences*, 44, 82–85. [胡文强, 温暖玲, 肖玉, 钟任资, 茹正忠 (2017). 短序润楠的地理分布及潜在分布区估计. *广东农业科学*, 44, 82–85.]
- Wu XK, Nan CH, Tang GG, Li Y, Mao LJ, Zhang ZC (2016). Impact of climate change on potential distribution range and spatial pattern of *Phoebe chekiangensis*. *Journal of Nanjing Forestry University (Natural Sciences Edition)*, 40, 85–91. [吴显坤, 南程慧, 汤庚国, 李垚, 毛丽君, 张志成 (2016). 气候变化对浙江楠潜在分布范围及空间格局的影响. *南京林业大学学报 (自然科学版)*, 40, 85–91.]
- Wu XY, Dong SK, Liu SL, Liu QR, Han YH, Zhang XL, Su XK, Zhao HD, Feng J (2018). Identifying priority areas for grassland endangered plant species in the Sanjiangyuan Nature Reserve based on the MaxEnt model. *Biodiversity Science*, 26, 138–148. [武晓宇, 董世魁, 刘世梁, 刘全儒, 韩雨晖, 张晓蕾, 苏旭坤, 赵海迪, 冯憬 (2018). 基于 MaxEnt 模型的三江源区草地濒危保护植物热点区识别. *生物多样性*, 26, 138–148.]
- Xiao M, Hu WZ, Dong L (2017). Potential geographical distribution of *Pinus tabulaeformis* by using MaxEnt model. *Geospatial Information*, 15, 34–37. [肖敏, 胡卓玮, 董琳 (2017). 基于 MaxEnt 模型的油松潜在地理分布研究. *地理空间信息*, 15, 34–37.]
- Xie BC, Du DS, Lu KD, Duan JQ, Liu FL (2015). Research on double rice climatic suitability planting regions based on MaxEnt model in Hunan. *Chinese Agricultural Science Bulletin*, 31, 247–251. [谢佰承, 杜东升, 陆魁东, 段居琦, 刘富来 (2015). 基于 MaxEnt 模型湖南双季稻种植气候适宜性分布研究. *中国农学通报*, 31, 247–251.]
- Xie DF, Tong F, Yang LJ, He XJ (2017). Potential distributions of an invasive species *Conyza bonariensis* (Compositae) in China as predicted by MaxEnt. *Journal of Sichuan University (Natural Science Edition)*, 3, 209–214. [谢登峰, 童芬, 杨丽娟, 何兴金 (2017). MaxEnt 模型下的外来入侵种香丝草在中国的潜在分布区预测. *四川大学学报 (自然科学版)*, 3, 209–214.]
- Xiong HX, Ding L, Xu H (2017). Ecological suitability regionalization of *Sophora flavescens* in Bijie Prefecture. *Guizhou Agricultural Sciences*, 45, 90–94. [熊厚溪, 丁铃, 许海 (2017). 毕节地区苦参的生态适宜性区划. *贵州农业科学*, 45, 90–94.]
- Xu CM, He SL, Yang Y, Shao Q, Wu HZ (2015). Prediction of potential distribution areas of *Gentiana rubicunda* and its suitability analysis. *Journal of West China Forestry Science*, 44, 63–68. [许春梅, 贺水莲, 杨扬, 邵青, 吴红芝 (2015). 深红龙胆的潜在分布区预测及适生性分级. *西部林业科学*, 44, 63–68.]
- Xu DY, Yan H (2001). A study of the impacts of climate change on the geographic distribution of *Pinus koraiensis* in China. *Environment International*, 27, 201–205.
- Xu FS, Li WL, Fan F, Song J, Wang XM (2018). Suitable area of growth prediction of *Semiaquilegia adoxoides* under the impact of climate change. *Shaanxi Forest Science and Technology*, 46, 1–5. [许福生, 李文丽, 樊凯, 宋杰, 王戎梅 (2018). 气候变化背景下天葵的适生区分布预测. *陕西林业科技*, 46, 1–5.]
- Xu J, Cao B, Bai CK (2015). Prediction of potential suitable distribution of endangered plant *Kingdonia uniflora* in China with MaxEnt. *Chinese Journal of Ecology*, 34, 3354–3359. [徐军, 曹博, 白成科 (2015). 基于 MaxEnt 濒危植物独叶草的中国潜在适生分布区预测. *生态学杂志*, 34, 3354–3359.]

- Xu J, Deng M, Jiang XL, Westwood M, Song YG, Turkington R (2015). Phylogeography of *Quercus glauca* (Fagaceae), a dominant tree of East Asian subtropical evergreen forests, based on three chloroplast DNA interspace sequences. *Tree Genetics Genomes*, 11, 805.
- Xu X, Zhang HY, Xie T, Xu Y, Zhao L, Tian W (2017). Effects of climate change on the potentially suitable climatic geographical range of *Liriodendron chinense*. *Forests*, 8, 399.
- Xu XT, Yang Y, Wang LS (2008). Geographic distribution and potential distribution estimation of *Pseudotsuga schenckii*. *Journal of Plant Ecology (Chinese Version)*, 32, 1134–1145. [徐晓婷, 杨永, 王利松 (2008). 白豆杉的地理分布及潜在分布区估计. *植物生态学报*, 32, 1134–1145.]
- Xu Z, Zhang ML (2015). The effect of past climatic oscillations on spatial genetic structure of *Atriplex manshurica* (Polygonoideae) in the Horqin sandlands, northern China. *Biochemical Systematics Ecology*, 60, 88–94.
- Xu ZD, Ding GH, Liu BD, Chi CY, Xiao W, Jin XX, Li CY (2012). Geographic distribution and prediction of potential suitable regions of *Iva xanthifolia*. *Acta Prataculturae Sinica*, 21, 75–83. [许志东, 丁国华, 刘保东, 池春玉, 肖玮, 金晓霞, 李春烨 (2012). 假苍耳的地理分布及潜在适生区预测. *草业学报*, 21, 75–83.]
- Xu ZL, Peng HH, Feng ZD, Abdulsalih N (2014). Predicting current and future invasion of *Solidago canadensis*: A study from China. *Polish Journal of Ecology*, 62, 263–272.
- Xu ZL, Zhao CY, Feng ZD (2011). Species potential distribution models and evaluation based on dissimilarity index of variables of Qinghai spruce (*Picea crassifolia*) in Qilian mountains. *Journal of Lanzhou University (Natural Sciences)*, 47, 55–63. [许仲林, 赵传燕, 冯兆东 (2011). 祁连山青海云杉林物种分布模型与变量相异指数. *兰州大学学报*, 47, 55–63.]
- Xu ZL, Zhao CY, Feng ZD (2012). Species distribution models to estimate the deforested area of *Picea crassifolia* in arid region recently protected: Qilian Mts. National Natural Reserve (China). *Polish Journal of Ecology*, 60, 515–524.
- Xu ZL, Zhao CY, Feng ZD, Peng HH, Wang C (2009). The impact of climate change on potential distribution of species in semi-arid region: a case study of Qinghai spruce (*Picea crassifolia*) in Qilian Mountain, Gansu Province, China. In: 2009 IEEE International Geoscience and Remote Sensing Symposium, Cape Town, 412–415.
- Xu ZP (2017). Study on the Population and Adaptability Character of *Gymnocarpus przewalskii* Maxim. In Desert Area. Doctor dissertation, Inner Mongolia Agricultural University, Huhehaote. [徐振朋 (2017). 荒漠区裸果木种群分布与性状适应特征研究. 博士学位论文, 内蒙古农业大学, 呼和浩特.]
- Yan H, Zhang XB, Zhu SD, Qian DW, Guo LP, Huang LQ, Duan JA (2016). Production regionalization study of Chinese angelica based on MaxEnt model. *China Journal of Chinese Materia Medica*, 41, 3139–3147. [严辉, 张小波, 朱寿东, 钱大玮, 郭兰萍, 黄璐琦, 段金廛 (2016). 当归药材生产区划研究. *中国中药杂志*, 41, 3139–3147.]
- Yan HF, Zhang CY, Wang FY, Hu CM, Ge XJ, Hao G (2012). Population expanding with the phalanx model and lineages split by environmental heterogeneity: a case study of *Primula obconica* in subtropical China. *Plos One*, 7, e41315.
- Yang B, Xue YG, Tang XF, Wang Y, Zhang MD (2009). Predicting potential geographic distribution of *Eupatorium odoratum* in China. *Plant Protection*, 35, 70. [杨波, 薛跃规, 唐小飞, 王媛, 张达敏 (2009). 外来入侵植物飞机草在中国的适生区预测. *植物保护*, 35, 70.]
- Yang HF, Zhen JH, Wu XL, Mu C (2015). Forecast of potential distribution area of *Aconitum leucostomum* in China based on MaxEnt model and ArcGIS. *China Plant Protection*, 35, 50–54. [杨会枫, 郑江华, 吴秀兰, 穆晨 (2015). 基于 MaxEnt 模型和 ArcGIS 的白喉乌头在中国潜在分布区预测. *中国植保导刊*, 35, 50–54.]
- Yang HF, Zheng JH, Jia XG, Liu XJ (2017). Projection of potential geographic distribution of *Apocynum venetum* under climate change in northern China. *China Journal of Chinese Materia Medica*, 42, 1119–1124. [杨会枫, 郑江华, 贾晓光, 李晓瑾 (2017). 气候变化下罗布麻潜在地理分布区预测. *中国中药杂志*, 42, 1119–1124.]
- Yang JX, Wang LH, Xu XN (2013). MaxEnt based geographic distribution pattern of *Malus toringo*. *Journal of Northwest A&F University (Natural Science Edition)*, 41, 172–176+182. [杨俊仙, 王雷宏, 徐小牛 (2013). 基

- 于 MaxEnt 模拟三叶海棠的地理分布. 西北农林科技大学学报, 41, 172–176+182.]
- Yang X, Zheng JH, Mu C, Lin J (2017). Predictions of potential geographical distribution of *Alhagi sparsifolia* under climate change. *China Journal of Chinese Materia Medica*, 42, 450–455. [杨霞, 郑江华, 穆晨, 林峻 (2017). 气候变化下骆驼刺潜在地理分布区预测. *中国中药杂志*, 42, 450–455.]
- Yang Y, Wei HY, Wang D, Shang ZH, Mao YJ, Yang HY, Gu W (2016). Comparison of the prediction models of the potential geographical distribution of *Forsythia suspense*. *Chinese Journal of Ecology*, 35, 2562–2568. [杨洋, 卫海燕, 王丹, 尚忠慧, 毛亚娟, 杨贺雨, 顾蔚 (2016). 连翘潜在地理分布预测模型的比较. *生态学杂志*, 35, 2562–2568.]
- Yang ZX, Zhou GS, Yin XJ, Jia BR (2014). Geographic distribution of *Larix gmelinii* natural forest in China and its climatic suitability. *Chinese Journal of Ecology*, 33, 1429–1436. [杨志香, 周广胜, 殷晓洁, 贾丙瑞 (2014). 中国兴安落叶松天然林地理分布及其气候适宜性. *生态学杂志*, 33, 1429–1436.]
- Ye YC, Zhou GS, Yin XJ (2016). Changes in distribution and productivity of steppe vegetation in Inner Mongolia during 1961 to 2010: Analysis based on MaxEnt model and synthetic model. *Acta Ecologica Sinica*, 36, 4718–4728. [叶永昌, 周广胜, 殷晓洁 (2016). 1961–2010 年内蒙古草原植被分布和生产力变化—基于 MaxEnt 模型和综合模型的模拟分析. *生态学报*, 36, 4718–4728.]
- Yi YJ, Cheng X, Yang ZF, Zhang SH (2016). Maxent modeling for predicting the potential distribution of endangered medicinal plant (*H. riparia* Lour) in Yunnan, China. *Ecological Engineering*, 92, 260–269.
- Yin XJ, Zhou GS (2015). Climatic suitability of the potential geographic distribution of *Fagus longipetiolata* in China. *Environmental Earth Sciences*, 73, 1143–1149.
- Yin XJ, Zhou GS, Sui XH, He QJ, Li RP (2013). Dominant climatic factors of *Quercus mongolica* geographical distribution and their thresholds. *Acta Ecologica Sinica*, 33, 103–109. [殷晓洁, 周广胜, 隋兴华, 何奇瑾, 李荣平 (2013). 蒙古栎地理分布的主导气候因子及其阈值. *生态学报*, 33, 103–109.]
- Yin XJ, Zhou GS, Sui XH, He QJ, Li RP (2013). Potential geographical distribution of *Quercus wutaishanica* forest and its dominant factors. *Scientia Silvae Sinicae*, 49, 10–14. [殷晓洁, 周广胜, 隋兴华, 何奇瑾, 李荣平 (2013). 辽东栎林潜在地理分布及其主导因子. *林业科学*, 49, 10–14.]
- Ying LX, Liu Y, Chen ST, Shen ZH (2016). Simulation of the potential range of *Pistacia weinmannifolia* in Southwest China with climate change based on the maximum-entropy (Maxent) model. *Biodiversity Science*, 24, 453–461. [应凌霄, 刘晔, 陈绍田, 沈泽昊 (2016). 气候变化情景下基于最大熵模型的中国西南地区清香木潜在分布格局模拟. *生物多样性*, 24, 453–461.]
- Yu DL, Yang HP, Yang ZB (2017). Potential distribution prediction of *Vanda coerulea* in Xishuangbanna. *Forest Inventory and Planning*, 42, 43–47. [余东莉, 杨鸿培, 杨正斌 (2017). 西双版纳大花万代兰潜在分布区预测. *林业调查规划*, 42, 43–47.]
- Yu FY, Groen T A, Wang TJ, Skidmore A K, Huang JH, Ma KP (2017). Climatic niche breadth can explain variation in geographical range size of alpine and subalpine plants. *International Journal of Geographical Information Science*, 31, 190–212.
- Yu FY, Skidmore A K, Wang TJ, Huang JH, Ma KP, Groen T A (2017). *Rhododendron* diversity patterns and priority conservation areas in China. *Diversity Distributions*, 23, 1143–1156.
- Yu HB, Zhang YL, Li SC, Qi W, Hu ZJ (2014). Predicting the dispersal routes of alpine plant *Pedicularis longiflora* (Orobanchaceae) based on GIS and species distribution models. *Chinese Journal of Applied Ecology*, 25, 1669–1673. [于海彬, 张镔铨, 李士成, 祁威, 胡忠俊 (2014). 基于 GIS 和物种分布模型的高山植物长花马先蒿迁移路线模拟. *应用生态学报*, 25, 1669–1673.]
- Yu J, Tang YX, Guo SL (2012). Comparison of the geographical distribution of *Racomitrium* and *Grimmia* in China using ArcGis and MaxEnt software. *Plant Science Journal*, 30, 443–458. [于晶, 唐艳雪, 郭水良 (2012). 基于 GIS 和 MaxEnt 比较中国砂藓属与紫萼藓属植物地理分布. *植物科学学报*, 30, 443–458.]

- Yu JH, Wang CJ, Wan JZ, Han SJ, Wang QG, Nie SM (2014). A model-based method to evaluate the ability of nature reserves to protect endangered tree species in the context of climate change. *Forest Ecology and Management*, 327, 48–54.
- Yue MF, Feng L, Cui Y, Zhang C, Tian XS (2016). Prediction of the potential distribution and suitability analysis of the invasive weed, *Bidens alba* (L.) DC. *Journal of Biosafety*, 25, 222–228. [岳茂峰, 冯莉, 崔烨, 张纯, 田兴山 (2016). 基于 MaxEnt 模型的入侵植物白花鬼针草的分布预测及适生性分析. *生物安全学报*, 25, 222–228.]
- Yue MF, Feng L, Tian XS, Yang CH (2013). MaxEnt-based prediction of potential distribution areas of *Mimosa pigra* L.. *Journal of Biosafety*, 22, 173–180. [岳茂峰, 冯莉, 田兴山, 杨彩宏 (2013). 基于 MaxEnt 的入侵植物刺轴含羞草的适生分布区预测. *生物安全学报*, 22, 173–180.]
- Yue MF, Feng L, Tian XS, Yang CH, Lü LH, Li WH (2011). MaxEnt-based prediction of suitable distribution of *Ipomoea cairica* in China. *Weeds and Management*, 99, 103. [岳茂峰, 冯莉, 田兴山, 杨彩宏, 吕利华, 李伟华 (2011). 基于 MaxEnt 的五爪金龙在中国的适生分布区预测. *农田杂草与防控*, 99, 103.]
- Zeng C. Studies on Regional division of *Radix Sophorae Tonkinensis* in China. Master dissertation, Guangxi Normal University, Guilin. [曾成 (2015). 山豆根药材全国生产区划研究. 硕士学位论文, 广西师范大学, 桂林.]
- Zhang C, Chen L, Tian CM, Li T, Wang R, Yang QQ (2016). Predicting the distribution of dwarf mistletoe (*Arceuthobium sichuanense*) with GARP and MaxEnt models. *Journal of Beijing Forestry University*, 38, 23–34. [张超, 陈磊, 田呈明, 李涛, 汪荣, 杨启青 (2016). 基于 GARP 和 MaxEnt 的云杉矮槲寄生分布区的预测. *北京林业大学学报*, 38, 23–34.]
- Zhang CH, He J, Sun YY, Li K (2018). Prediction of distributional change of *Toona ciliata* var. *ciliate* and application in regionalization of introduction based on MaxEnt. *Journal of Yunnan University*, 40, 164–173. [张春华, 和菊, 孙永玉, 李昆 (2018). 基于 Maxent 模型的原种红椿适生区变迁预测及在引种区划上的应用. *云南大学学报*, 40, 164–173.]
- Zhang CH, He J, Sun YY, Li Q (2017). Distributional change in suitable areas for *Toona sureni* based on MaxEnt model. *Journal of Beijing Forestry University*, 39, 33–41. [张春华, 和菊, 孙永玉, 李昆 (2017). 基于 MaxEnt 模型的紫椿适生区预测. *北京林业大学学报*, 39, 33–41.]
- Zhang DF, Zhang Q, Guo J, Sun CZ, Wu J, Nie X, Xie CX (2017). Research on the global ecological suitability and characteristics of regions with *Angelica sinensis* based on the Maxent model. *Acta Ecologica Sinica*, 37, 5111–5120. [张东方, 张琴, 郭杰, 孙成忠, 吴杰, 聂祥, 谢彩香 (2017). 基于 MaxEnt 模型的当归全球生态适宜区和生态特征研究. *生态学报*, 37, 5111–5120.]
- Zhang F, Chen SQ, Wang LL, Zhang T, Zhang XB, Zhu SD (2017). Study on ecological suitability regionalization of *Corni fructus* based on Maxent and ArcGIS model. *China Journal of Chinese Materia Medica*, 42, 3078–3083. [张飞, 陈随清, 王利丽, 张涛, 张小波, 朱寿东 (2017). 基于 Maxent 和 ArcGIS 的山茱萸生态适宜性区划研究. *中国中药杂志*, 42, 3078–3083.]
- Zhang HJ, Chen Y, Huang LJ, Ni HW (2011). Predicting potential geographic distribution of *Mikania micrantha* planting based on ecological niche models in China. *Transactions of the CSAE*, 27, 413–418. [张海娟, 陈勇, 黄烈健, 倪汉文 (2011). 基于生态位模型的薇甘菊在中国适生区的预测. *农业工程学报*, 27, 413–418.]
- Zhang HL (2013). Analysis of suitable growth area and habitat of rare plant *Sinopodophyllum hexandrum* based on GARP niche model. *Acta Agriculturae Jiangxi*, 25, 112–115. [张海龙 (2013). 基于 GARP生态位模型的珍稀植物桃儿七适生区与生境分析. *江西农业学报*, 25, 112–115.]
- Zhang HL (2014). Potential Geographical Distribution of Traditional Chinese Medicine *Gentiana Macrophylla* Based on Niche Modeling. Master dissertation, Shaanxi Normal University, Xi'an. [张海龙 (2014). 基于生态位模型的传统中药秦艽潜在地理分布研究. 硕士学位论文, 陕西师范大学, 西安.]
- Zhang HL (2017). Using MaxEnt model to predict the potential geographical distribution of *Radix podophylli*. *Gansu Science and Technology*, 33, 39–42. [张海龙 (2017). 运用 MaxEnt 模型预测藏药桃儿七的潜在地理分布. *甘肃科学*, 33, 39–42.]

肃科技, 33, 39–42.]

- Zhang HX, Zhang ML (2014). Insight into distribution patterns and conservation planning in relation to woody species diversity in Xinjiang, arid northwestern China. *Biological Conservation*, 177, 165–173.
- Zhang HX, Zhang ML, Wang LN (2015). Genetic structure and historical demography of *Malus sieversii* in the Yili Valley and the western mountains of the Junggar Basin, Xinjiang, China. *Journal of Arid Land*, 7, 264–271.
- Zhang HX, Zhang ML, Williams DM (2014). Genetic evidence and species distribution modelling reveal the response of *Larix sibirica* and its related species to Quaternary climatic and ancient historical events. *Biochemical Systematics and Ecology*, 54, 316–325.
- Zhang J, Ao ZQ, Wu YM, Yang CY, Li M (2017). Prediction of potential geographic distribution of *Actinidia chinensis* in China based on maximum entropy niche model and ArcGIS. *Tropical Geography*, 37, 218–225. [张杰, 敖子强, 吴永明, 杨春燕, 李敏 (2017). 中华猕猴桃 (*Actinidia chinensis*) 在中国的适生性及其潜在地理分布模拟预测. *热带地理*, 37, 218–225.]
- Zhang JP, Zhang YL, Liu LS, Nie Y (2011). Predicting potential distribution of Tibetan spruce (*Picea smithiana*) in Qomolangma (Mount Everest) National Nature Preserve using maximum entropy niche-based model. *Chinese Geographical Science*, 21, 417.
- Zhang L (2015). Prediction of potential distribution area of *Euphorbia dentata* in China based on MAXENT model. *Journal of Biosafety*, 24, 194–200. [张路 (2015). 基于 MAXENT 模型预测齿裂大戟在中国的潜在分布区. *生物安全学报*, 24, 194–200.]
- Zhang L, Deng YQ, Xie DF, He XJ (2017). Prediction of potential distributions of *Peucedanum praeruptorum* and *Angelica decursiva* in China. *Journal of Sichuan University (Natural Science Edition)*, 54, 641–647. [张琳, 邓亦麒, 谢登峰, 何兴金 (2017). 前胡和紫花前胡在中国的潜在分布区预测. *四川大学学报 (自然科学版)*, 54, 641–647.]
- Zhang L, Liu SR, Sun PS, Wang LT (2011). Predicting the potential distribution of *Phyllostachys edulis* with DOMAIN and NeuralEnsembles Models. *Scientia Silvae Sinicae*, 47, 20–26. [张雷, 刘世荣, 孙鹏森, 王同立 (2011). 基于 DOMAIN和NeuralEnsembles 预测中国毛竹潜在分布. *林业科学*, 47, 20–26.]
- Zhang L, Liu SR, Sun PS, Wang TL (2011). Comparative evaluation of multiple models of the effects of climate change on the potential distribution of *Pinus massoniana*. *Chinese Journal of Plant Ecology*, 35, 1091–1105. [张雷, 刘世荣, 孙鹏森, 王同立 (2011). 气候变化对马尾松潜在分布影响预估的多模型比较. *植物生态学报*, 35, 1091–1105.]
- Zhang L, Liu SR, Sun PS, Wang TL, Wang GY, Wang LL, Zhang XD (2016). Using DEM to predict *Abies faxoniana* and *Quercus aquifolioides* distributions in the upstream catchment basin of the Min River in southwest China. *Ecological Indicators*, 69, 91–99.
- Zhang L, Liu SR, Sun PS, Wang TL, Wang GY, Zhang XD, Wang LL (2015). Consensus forecasting of species distributions: The effects of niche model performance and niche properties. *PLoS One*, 10, e0120056.
- Zhang L, Wang LL, Zhang XD, Liu SR, Sun PS, Wang TL (2014). The basic principle of random forest and its applications in ecology: A case study of *Pinus yunnanensis*. *Acta Ecologica Sinica*, 34, 650–659. [张雷, 王琳琳, 张旭东, 刘世荣, 孙鹏森, 王同立 (2014). 随机森林算法基本思想及其在生态学中的应用—以云南松分布模拟为例. *生态学报*, 34, 650–659.]
- Zhang LL (2014). Resources Suitability Evaluation and Determination of Genomic Size of Medicinal Species in Scutellaria. Master dissertation, Shaanxi Normal University, Xi'an. [张琳琳 (2014). 黄芩属药用植物资源适宜性评价及基因组大小测定. 硕士学位论文, 陕西师范大学, 西安.]
- Zhang LL, Cao B, Bai CK, Li GS, Mao MC (2016). Predicting suitable cultivation regions of medicinal plants with Maxent modeling and fuzzy logics: A case study of *Scutellaria baicalensis* in China. *Environmental Earth Sciences*, 75, 361.

- Zhang LY (2015). Research on geographic distribution and potential distribution of *Mucuna birdwoodiana*. *Guihaia*, 32, 27–32. [张蓝月 (2015). 白花油麻藤的地理分布及适生区预测. *广西植物*, 32, 27–32.]
- Zhang MG, Slik JW F, Ma KP (2016). Using species distribution modeling to delineate the botanical richness patterns and phytogeographical regions of China. *Scientific Reports*, 6, 22400.
- Zhang MG, Slik JW F, Ma KP (2017). Priority areas for the conservation of perennial plants in China. *Biological Conservation*, 210, 56–63.
- Zhang MG, Zhou ZK, Chen WY, Cannon CH, Raes N, Slik JWF (2014). Major declines of woody plant species ranges under climate change in Yunnan, China. *Diversity and Distributions*, 20, 405–415.
- Zhang MG, Zhou ZK, Chen WY, Slik JWF, Cannon CH, Raes N (2012). Using species distribution modeling to improve conservation and land use planning of Yunnan, China. *Biological Conservation*, 153, 257–264.
- Zhang Q, Zeng FL, Zhang DF, Xie CX, Chen SL (2016). Ecology suitability regions and ecological characteristics of *Panax notoginseng* (Burk.) F.H.Chen based on maximum entropy model. *Acta Pharmaceutica Sinica*, 51, 1629–1637. [张琴, 曾凡琳, 张东方, 谢彩香, 陈士林 (2016). 基于最大熵模型的三七生态适宜区及生态特征. *药学报*, 51, 1629–1637.]
- Zhang Q, Zhang DF, Wu ML, Guo J, Sun CZ, Xie CX (2017). Predicting the global areas for potential distribution of *Gastrodia elata* based on ecological niche models. *Chinese Journal of Plant Ecology*, 41, 770–778. [张琴, 张东方, 吴明丽, 郭杰, 孙成忠, 谢彩香 (2017). 基于生态位模型预测天麻全球潜在适生区. *植物生态学报*, 41, 770–778.]
- Zhang Q, Zhang XS (2012). Impacts of predictor variables and species models on simulating *Tamarix ramosissima* distribution in Tarim Basin, northwestern China. *Journal of Plant Ecology*, 5, 337–345.
- Zhang XB, Guo LP, Zhao MX, Wang H, Yang G, Jing ZX, Lu YY, Ye L, Ke X, Huang LQ (2016). Production suitability regionalization study of *Pinus massoniana*. *China Journal of Chinese Materia Medica*, 41, 3115–3121. [张小波, 郭兰萍, 赵曼茜, 王慧, 杨光, 景志贤, 卢有媛, 叶亮, 柯潇, 黄璐琦 (2016). 马尾松生产适宜性区划研究. *中国中药杂志*, 41, 3115–3121.]
- Zhang XQ, Li GQ, Du S (2018). Simulating the potential distribution of *Elaeagnus angustifolia* L. based on climatic constraints in China. *Ecological Engineering*, 113, 27–34.
- Zhang XW, Li Y, Fang YM (2014). Geographical distribution and prediction of potential ranges of *Quercus acutissima* in China. *Acta Botanica Boreali-Occidentalia Sinica*, 34, 1685–1692. [张兴旺, 李垚, 方炎明 (2014). 麻栎在中国的地理分布及潜在分布区预测. *西北植物学报*, 34, 1685–1692.]
- Zhang Y (2011). Prediction of Potential Suitable Distribution of Compositae Invasive Species from North America with Niche Modles Based on GIS. Master dissertation, Nanjing Agricultural University, Nanjing. [张颖 (2011). 基于GIS的生态位模型预测源自北美的菊科入侵物种的潜在适生区. 硕士学位论文, 南京农业大学, 南京.]
- Zhang Y, Li J, Lin W, Qiang S (2011). Prediction of potential distribution area of *Erigeron philadelphicus* in China based on MaxEnt model. *Chinese Journal of Applied Ecology*, 22, 2970–2976. [张颖, 李君, 林蔚, 强胜 (2011). 基于最大熵生态位元模型的入侵杂草春飞蓬在中国潜在分布区的预测. *应用生态学报*, 22, 2970–2976.]
- Zhang YB, Wang YZ, Zhang MG, Ma KP (2014). Climate change threats to protected plants of China: an evaluation based on species distribution modeling. *Chinese Science Bulletin*, 59, 4652–4659.
- Zhang ZD, Zang RG (2007). Predicting potential distributions of dominant woody plant keystone species in a natural tropical forest landscape of Bawangling, Hainan Island, south China. *Journal of Plant Ecology (Chinese Version)*, 31, 1079–1091. [张志东, 臧润国 (2007). 海南岛霸王岭热带天然林景观中主要木本植物关键种的潜在分布. *植物生态学报*, 31, 1079–1091.]
- Zhao XJ, Meng HX, Wang WH, Yan BQ (2016). Prediction of the distribution of alpine tree species under climate change scenarios: *Larix chinensis* in Taibai Mountain (China). *Polish Journal of Ecology*, 64, 200–213.
- Zhao ZF, Wei HY, Guo YL, Gu W (2016). Potential distribution of *Panax ginseng* and its predicted responses to climate

- change. Chinese Journal of Applied Ecology, 27, 3607–3615. [赵泽芳, 卫海燕, 郭彦龙, 顾蔚 (2016). 人参潜在地理分布以及气候变化对其影响预测. 应用生态学报, 27, 3607–3615.]
- Zheng H, He XJ (2011). Prediction of potential distribution of four alien invasive *Amaranthus* weeds in China. Plant Protection, 37, 81–86. [郑卉, 何兴金 (2011). 苋属4种外来有害杂草在中国的适生区预测. 植物保护, 37, 81–86.]
- Zhong GP (2008). Prediction of Potential Distribution of Alien Invasive Weeds in China. Master dissertation, Southwest University, Chongqing. [钟良平 (2008). 几种外来入侵杂草在我国的潜在分布预测. 硕士学位论文, 西南大学, 重庆.]
- Zhong GP, Shen WJ, Wan FH, Wang JJ (2009). Potential distribution areas of *Solanum rostratum* in China: A prediction with GARP niche model. Chinese Journal of Ecology, 28, 162–166. [钟良平, 沈文君, 万方浩, 王进军 (2009). 用 GARP 生态位模型预测刺萼龙葵在中国的潜在分布区. 生态学杂志, 28, 162–166.]
- Zhou DM, Zhang RZ, Sun WC, Zhang J, Wang HL (2014). Study on climatic suitability for winter rapeseed planting in arid and cold regions in north China. Scientia Agricultura Sinica, 47, 2541–2551. [周冬梅, 张仁陟, 孙万仓, 张军, 王鹤龄 (2014). 北方旱寒区冬油菜种植气候适宜性研究. 中国农业科学, 47, 2541–2551.]
- Zhou DM, Zhang RZ, Sun WC, Zhang J, Wang HL (2014). Evaluation of the suitability and influencing factors of winter rapeseed planting in Gansu Province. Chinese Journal of Eco-Agriculture, 22, 697–704. [周冬梅, 张仁陟, 孙万仓, 张军, 王鹤龄 (2014). 甘肃省冬油菜种植适宜性及影响因子评价. 中国生态农业学报, 22, 697–704.]
- Zhou GF, Liu JX, Li XJ, Xu N, Zhu WQ, Meng FY (2016). Evaluation for ecological adaptability of *Scutellariae Radix* and effects of environmental variables on chemical components. Chinese Journal of Experimental Traditional Medical Formulae, 22, 28–32. [周国富, 刘金欣, 李晓娟, 徐宁, 朱文全, 孟繁蕴 (2016). 黄芩生态适宜性评价及生态因子对 5 种主要指标性成分的影响. 中国实验方剂学杂志, 22, 28–32.]
- Zhou J (2012). Studies on the Potential Distribution of *Miscanthus sinensis* Anderss and *M. Floridulus* (Lab.) Ward in China Based on Temperature and Precipitation. Master dissertation, Hunan Agricultural University, Changsha. [周婧 (2012). 基于温度和降水的芒和五节芒在中国的潜在分布研究. 硕士学位论文, 湖南农业大学, 长沙.]
- Zhou J, Li QY, Xiao L, Jiang JX, Yi ZL (2012). Potential distribution of *Miscanthus sinensis* and *M. floridulus* in China. Chinese Journal of Plant Ecology, 36, 504–510. [周婧, 李巧云, 肖亮, 蒋建雄, 易自力 (2012). 芒和五节芒在中国的潜在分布. 植物生态学报, 36, 504–510.]
- Zhou P, Qian ZQ, Chen KK, Qiang Y (2015). Prediction of suitable area of *Sedum aizoon* L. in China under climate change. Journal of Chinese Medicinal Materials, 38, 1379–1383. [周佩, 钱增强, 陈克克, 强毅 (2015). 气候变化背景下费菜在中国适生区分布预测. 中药材, 38, 1379–1383.]
- Zhou XR, Yu Y, Zhou SD, He XJ (2012). Geographic distribution and potential distribution of *Torreya fargesii*. Scientia Silvae Sinicae, 48, 1–8. [周先容, 余岩, 周颂东, 何兴金 (2012). 巴山榿树地理分布格局及潜在分布区. 中药材, 48, 1–8.]
- Zhou Y, Li Y, Wang SM (2015). Suitable habitats prediction of original plants of *Rhei Radix et Rhizoma* under climate change. Journal of Chinese Medicinal Materials, 38, 467–472. [周云, 李延, 王戌梅 (2015). 气候变化背景下中药大黄原植物的适生区分布预测. 中药材, 38, 467–472.]
- Zhu GP, Liu Q, Gao YB (2014). Improving ecological niche model transferability to predict the potential distribution of invasive exotic species. Biodiversity Science, 22, 223–230. [朱耿平, 刘强, 高玉葆 (2014). 提高生态位模型转移能力来模拟入侵物种的潜在分布. 生物多样性, 22, 223–230.]
- Zhu H, You LX, Li YF, Wang HC, Wang XR (2017). Modeling the geographical distribution pattern and climatic limited factors of *Cerasus schneideriana*. Journal of Tropical and Subtropical Botany, 25, 315–322. [朱弘, 尤禄祥, 李涌福, 王华辰, 王贤荣 (2017). 浙闽樱桃地理分布模拟及气候限制因子分析. 热带亚热带植物学报, 25, 315–322.]
- Zhu JM, Li YF, Zhang L, Li B, Gao MY, Tang XQ, Ni JW, Xu XQ (2017). Potential distribution range and conservation

- strategies for the endangered species *Amygdalus pedunculat*. *Biodiversity Science*, 25, 799–806. [褚建民, 李毅夫, 张雷, 李斌, 高明远, 唐晓倩, 倪建伟, 许新桥 (2017). 濒危物种长柄扁桃的潜在分布与保护策略. 生物多样性, 25, 799–806.]
- Zhu L (2007). Competitive Strategy and Spatial Dispersal of Invasive Plant *Eupatorium Adenophorum*. Doctor dissertation, Institute of Botany, Chinese Academy of Science, Beijing. [朱丽 (2007). 外来入侵种紫茎泽兰竞争策略与扩散动态. 博士学位论文, 中国科学院植物研究所, 北京.]
- Zhu L, Sun O J, Sang WG, Li ZY, Ma KP (2007). Predicting the spatial distribution of an invasive plant species (*Eupatorium adenophorum*) in China. *Landscape Ecology*, 22, 1143–1154.
- Zhu LN (2015). Suitable Habitat Division of Three Species *Scutellaria* and Their Response to Climate Change. Master dissertation, Shaanxi Normal University, Xi'an. [朱俐南 (2015). 黄芩属三种植物适宜生境区划及其对气候变化的响应. 硕士学位论文, 陕西师范大学, 西安.]
- Zhu LN, Wei HY, Guo YL, Sang MJ, Cui JL, Gu W (2015). Suitable habitat division of *Scutellaria baicalensis georgi* based on entropy weight and matter element model. *Bulletin of Soil and Water Conservation*, 35, 153–158. [朱俐南, 卫海燕, 郭彦龙, 桑满杰, 崔晋亮, 顾蔚 (2015). 基于熵权物元模型的黄芩适宜生境区划. 水土保持通报, 35, 153–158.]
- Zhu ZL, Huo Y, Li YN (2015). Distribution prediction of eight kinds of woody plants and adaptability analysis and landscape application in Lixia river region Jiangsu province. *Journal of Central South University of Forestry & Technology*, 35, 1–6. [祝遵凌, 火艳, 李燕楠 (2015). 八种木本植物分布区预测及适生性分析与景观应用研究. 中南林业科技大学学报, 35, 1–6.]
- Zong M, Han GX, Li YZ, Wang GZ, Wang AD, Yang XJ (2017). Predicting the potential distribution of dominant species of the coastal wetland in the Yellow River Delta, China using MaxEnt model. *Chinese Journal of Applied Ecology*, 28, 1833–1842. [宗敏, 韩广轩, 栗云召, 王光镇, 王安东, 杨显基 (2017). 基于 MaxEnt 模型的黄河三角洲滨海湿地优势植物群落潜在分布模拟. 应用生态学报, 28, 1833–1842.]
- Zuo WY (2006). Predict *Rhododendron L.* Potential Distribution Center in China by SVM. Master dissertation, Institute of Botany, Chinese Academy of Sciences, Beijing. [左闻韵 (2006). 应用 SVM 预测杜鹃属 (*Rhododendron L.*) 在中国的潜在分布中心. 硕士学位论文, 中国科学院植物研究所, 北京.]