

千岛湖片段化景观生物多样性监测与研究

丁 平 于明坚

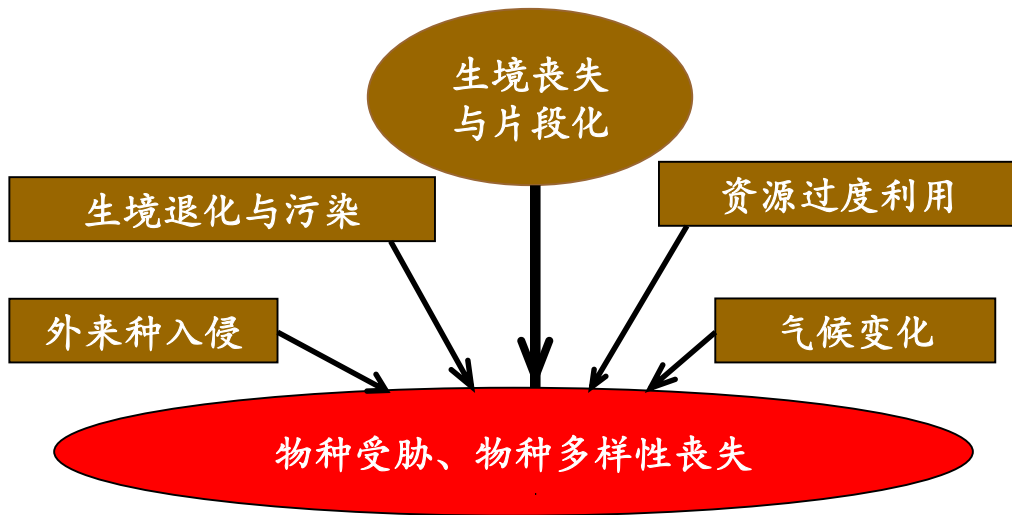
浙江大学生命科学学院



浙江大学

1 引言

- 人类正面临着前所未有的生物多样性丧失和物种灭绝危机!



□ 最重要胁迫因素

● 栖息地的丧失与片段化

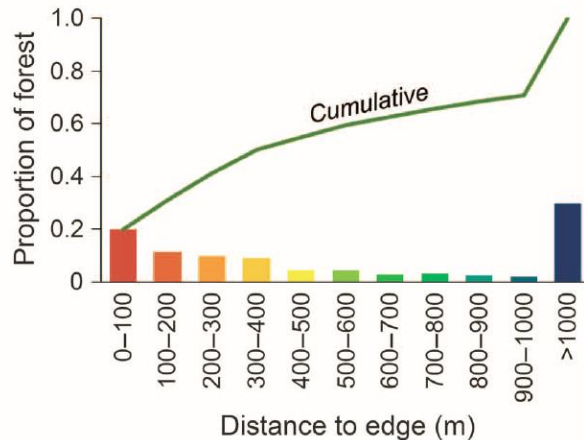
我国大多数森林斑块面积很小，大部分面积小于10公顷

BIOLOGICAL
REVIEWS
Biol. Rev. (2019), 94, pp. 1636–1657.
doi: 10.1111/rev.12319
Cambridge
Philosophical Society
1636

Forest fragmentation in China and its effect on biodiversity

Jiajia Liu^{1,2}, David A. Coomes^{2,*}, Luke Gibson³, Guang Hu⁴, Jinliang Liu¹, Yangqing Luo¹, Chuping Wu^{1,3} and Mingjian Yu^{1,*}

Global

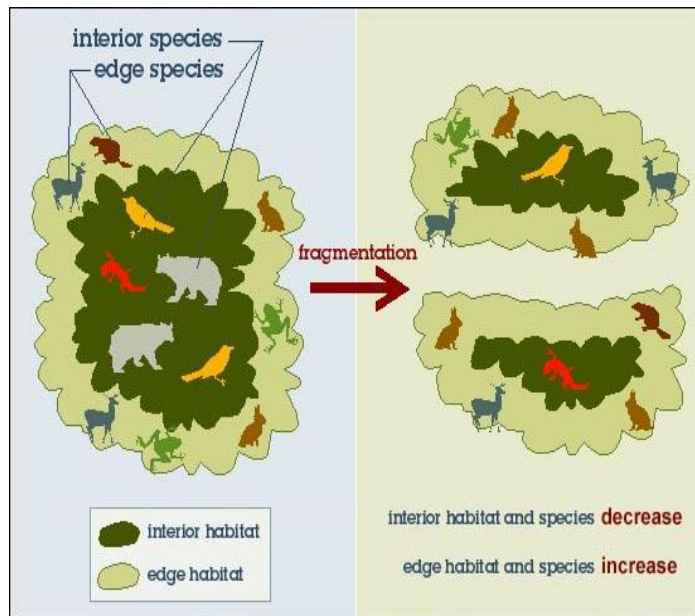


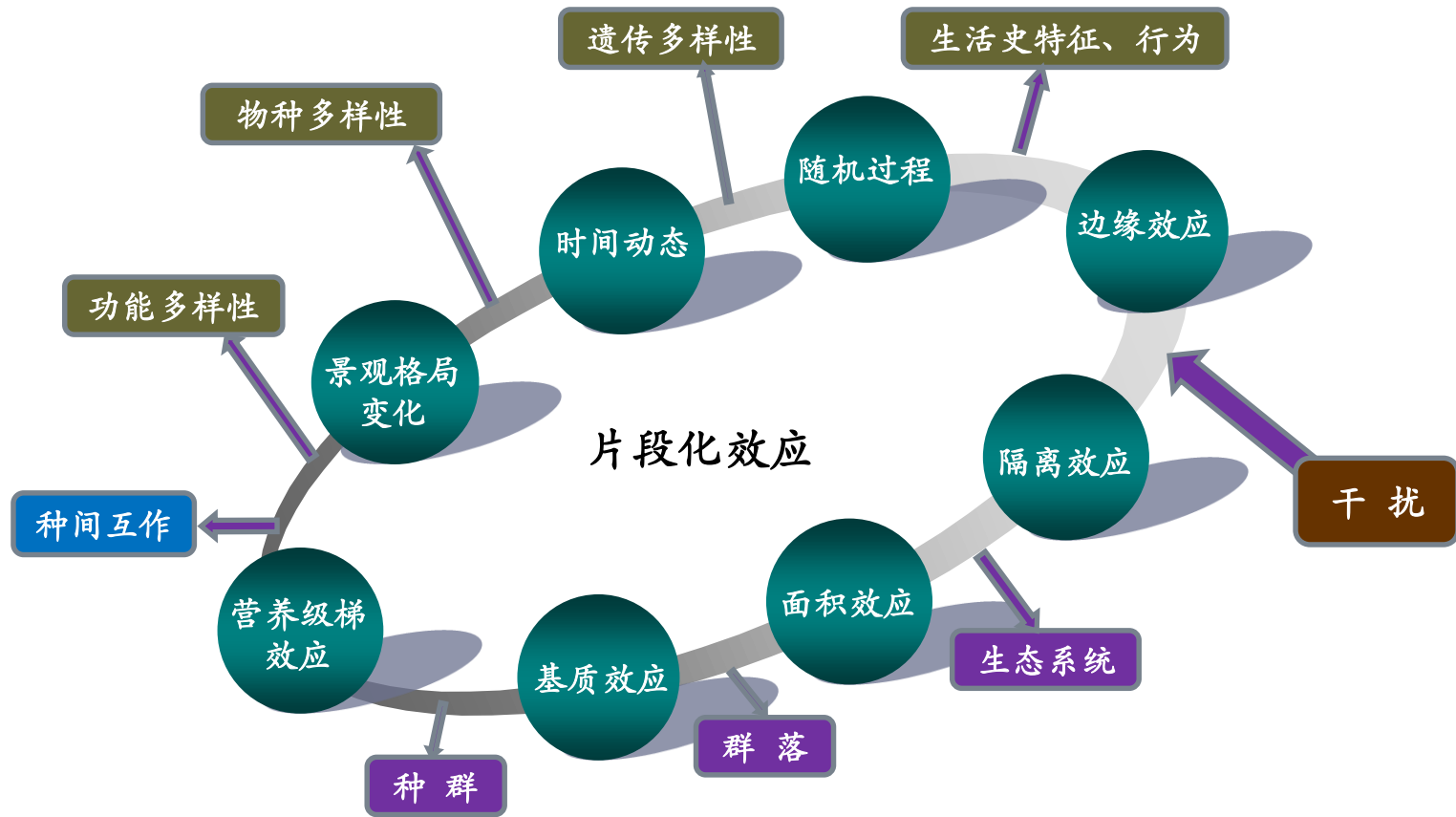
全世界超过70% 的森林
其林缘距离在1 km 以内

Haddad *et al.* 2015

生境片段化后的景观变化

- 生境面积总量减少
- 斑块增多
- 斑块面积变小
- 斑块间隔离度增加
- 单位面积生境边界变长
- 生境中心到边界距离变短





□ 生境片段化问题成为当今生态学与保护生物学研究领域的核心与前沿问题之一

关注的科学问题

- 群落构建（聚群）规律与物种共存机制
 - 多维度生物多样性的时空格局及其维持机制
 - 食物网结构和物种相互作用的变化规律
 - 生物多样性与生态系统功能之间的关系
 - 片段化生境中生物多样性保护策略
-

Community assembly, diversification, ecosystem functioning, genomics, island biogeography, islands as model systems, speciation.

□ 修建水库大坝形成的陆桥岛屿为研究生物多样性、岛屿生物地理学和生境片段化效应等科学提供了理想的研究平台！



Dammed Experiments!
Jared Diamond
Science **294**, 1847 (2001);
DOI: 10.1126/science.1067012

ECOLOGY **POLICY FORUM**

**Three-Gorges Dam—Experiment
in Habitat Fragmentation?**

Jianguo Wu,^{1,2} Jianhui Huang,² Xingguo Han², Zongqiang Xie², Xianming Gao²

Wu et al. 2003

graphically unique to the Yangtze River (19).
The TGD will affect biodiversity and ecological processes in the area through both the immediate loss of habitat area and increased isolation of remaining habitat patches. The ecological impacts of TGD will become evident at several levels. For

人工陆桥岛屿的特征

- ❑ 形成时间一致、形成历史清楚
- ❑ 基质为水，单一、不亲和性
- ❑ 岛屿边缘明显、岛屿生境相对一致

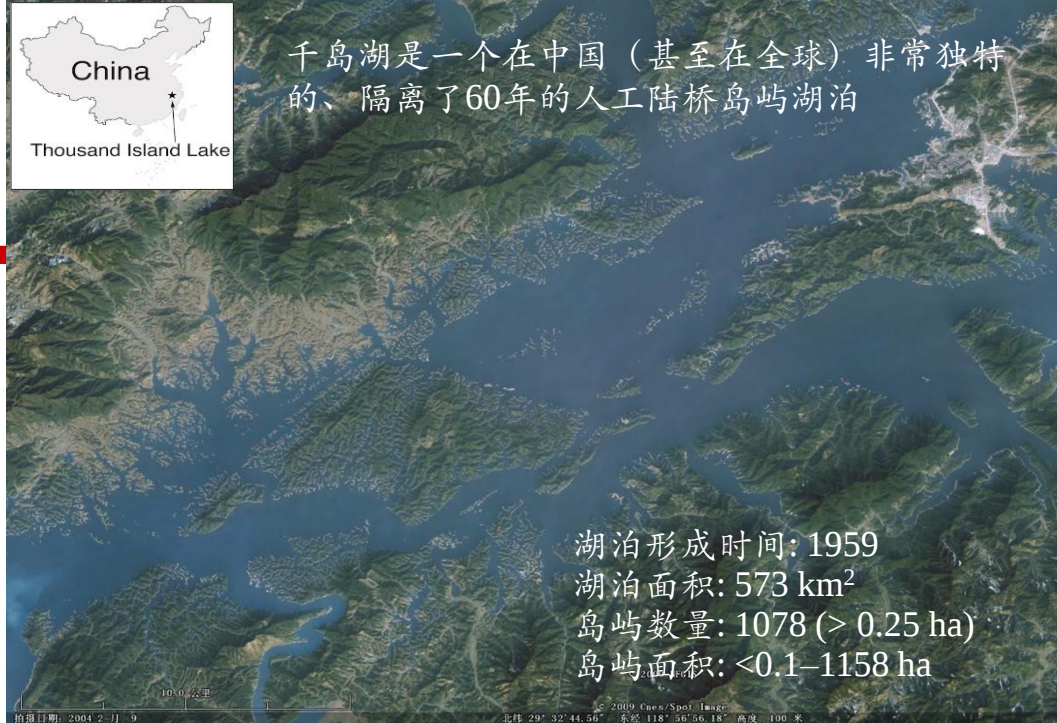


千岛湖概况

□ 浙江省西部淳安县



千岛湖是一个在中国（甚至在全球）非常独特的、隔离了60年的人工陆桥岛屿湖泊



湖泊形成时间: 1959

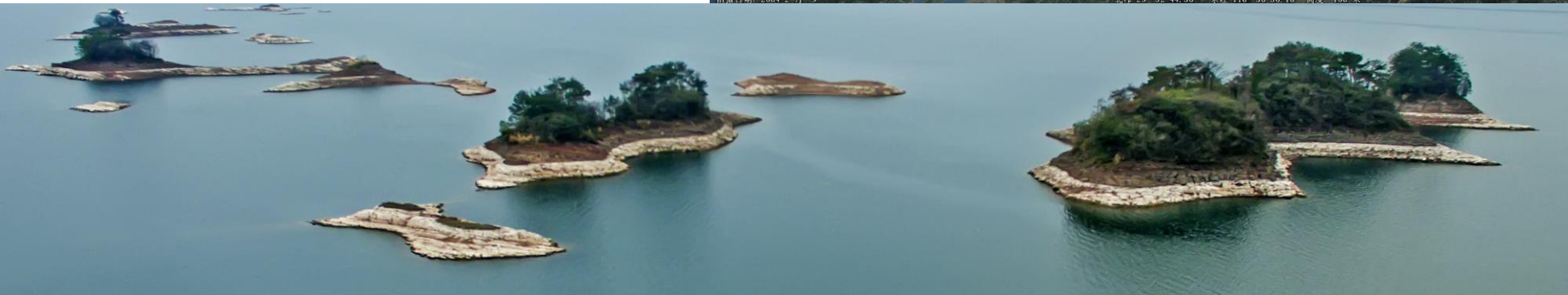
湖泊面积: 573 km²

岛屿数量: 1078 (> 0.25 ha)

岛屿面积: <0.1–1158 ha

拍摄日期: 2004-2-11-9

© 2009 Cnes/Spot Image
北纬 29° 32' 44.56" 东经 118° 56' 56.18" 海拔 100 米

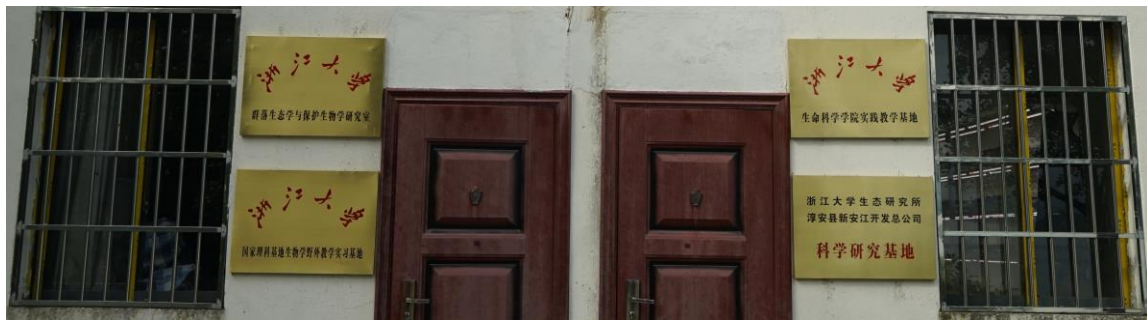




千岛湖地区的主要植被类型：次生马尾松林

千岛湖生态学野外科学观测研究站

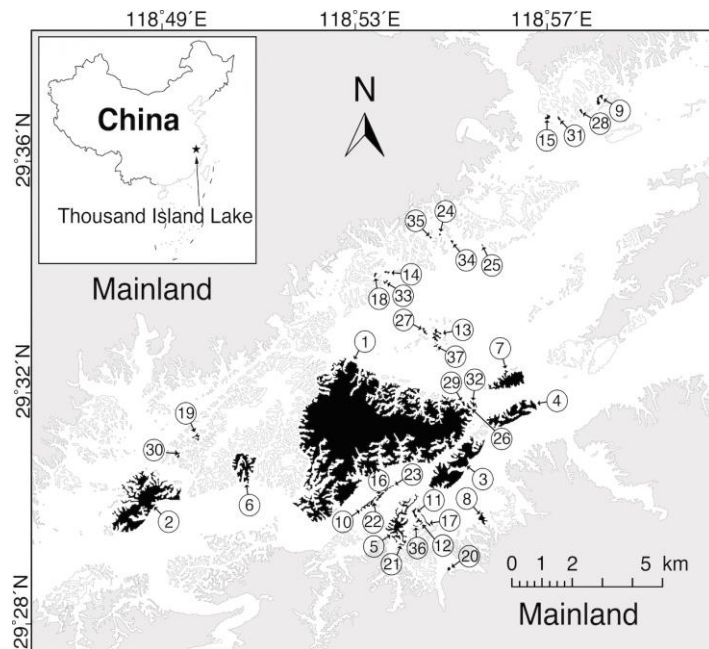
- ❑ 16年的长期定位研究
- ❑ 2008年建站
- ❑ 具国际影响的独特片段化研究平台

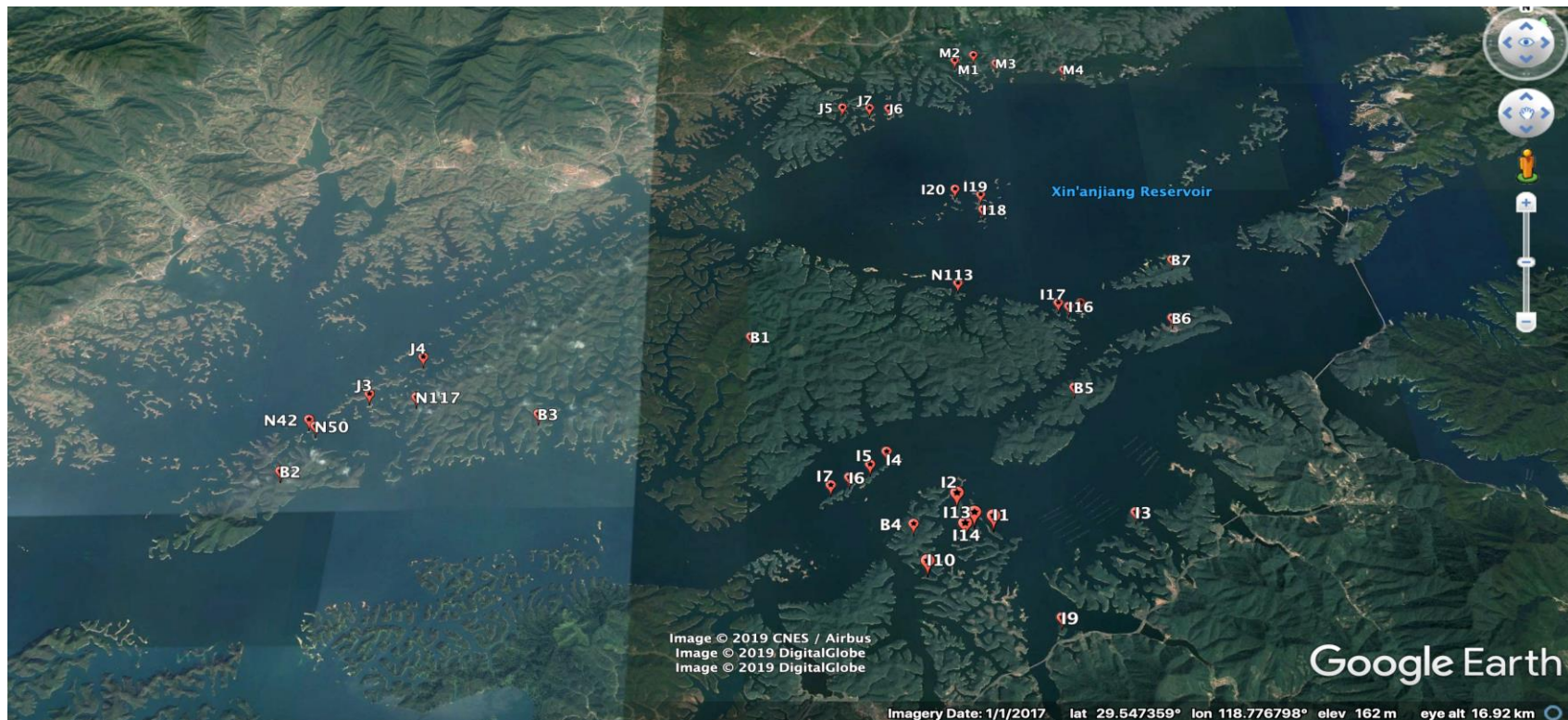




3 在千岛湖已开展的监测与调查工作

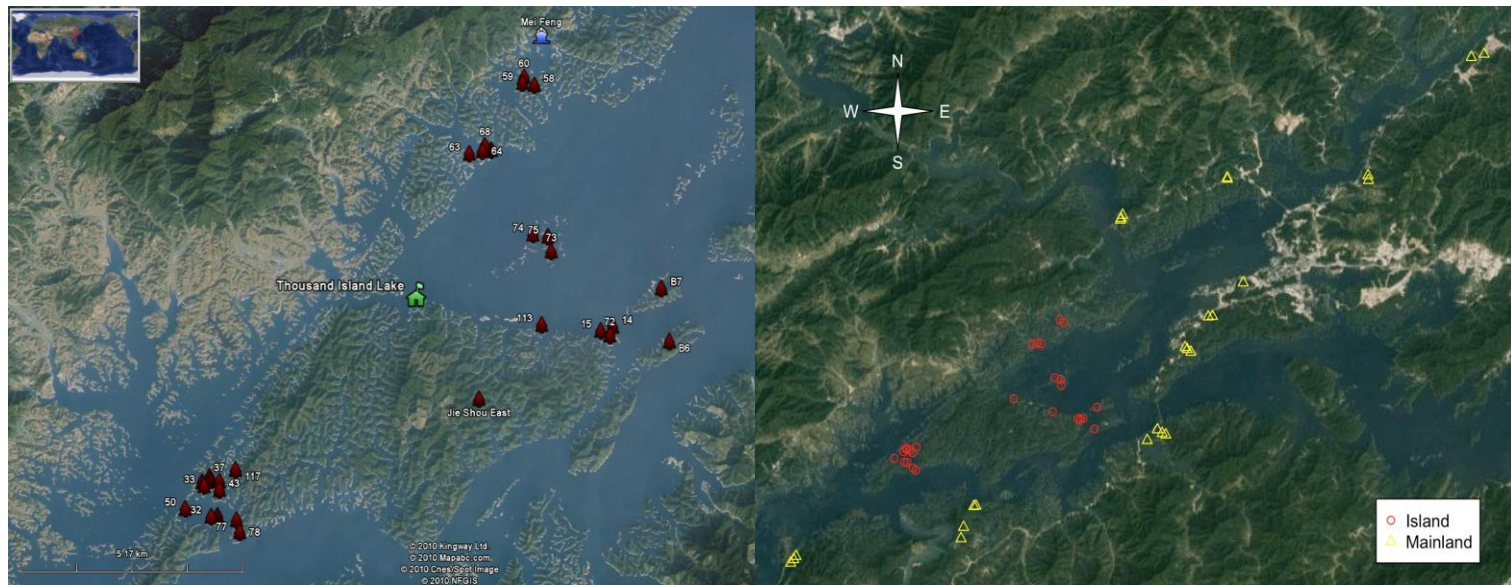
- 42个岛：鸟类长期监测固定样线
- ✓ 2003年开始调查；2006年扩展到42个岛
- ✓ 调查季节：繁殖季（4-6月）、冬季（11-1月）
- ✓ 每月调查15次，2011年起9次



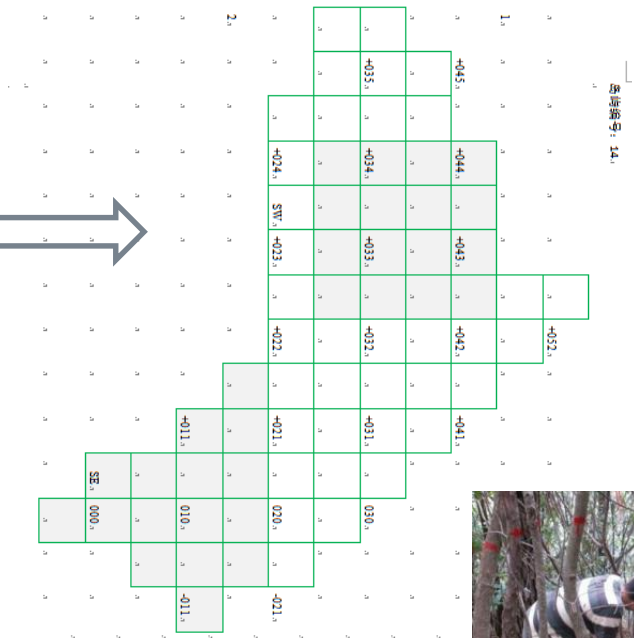
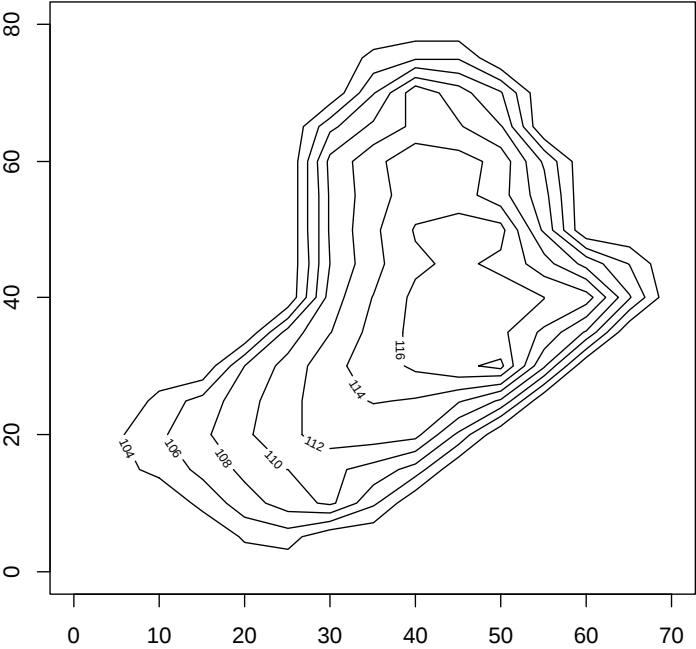


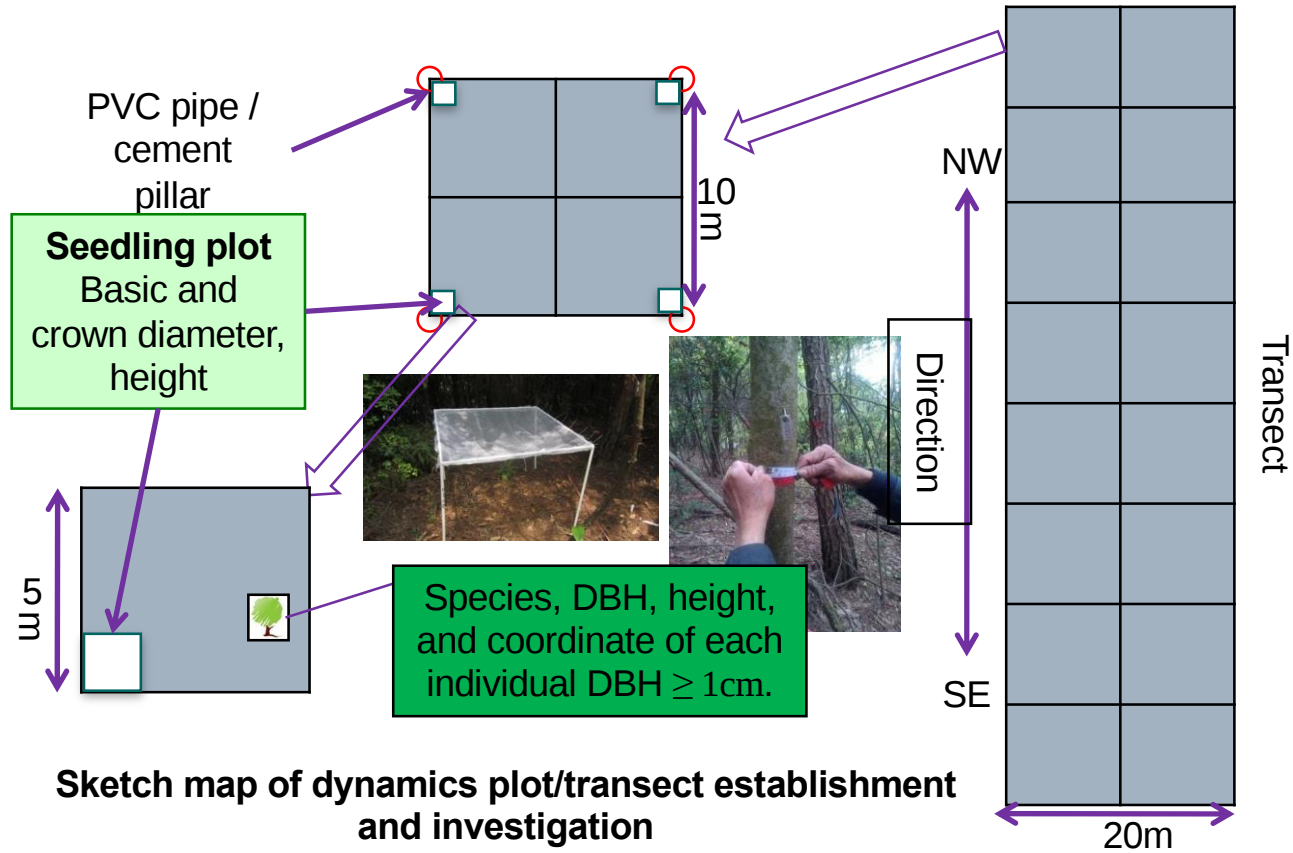
植物群落动态监测样地 (29样岛+大陆样地)

地点	面积	样方	设置时间	复查1	复查2
20 小岛 (<1ha)	7.91ha	1918: 5m×5m (全岛)	2009-2010	2014-2015	2019
9 大岛(1-1154ha)	4.80ha	3165: 5m×5m (至少0.5ha)			
大陆	1.00ha	1: 100m×100m	2012	2017	
大陆	1.25ha	21: 30m×30m			
大陆	1.89ha	5: 50m×50m	2016		

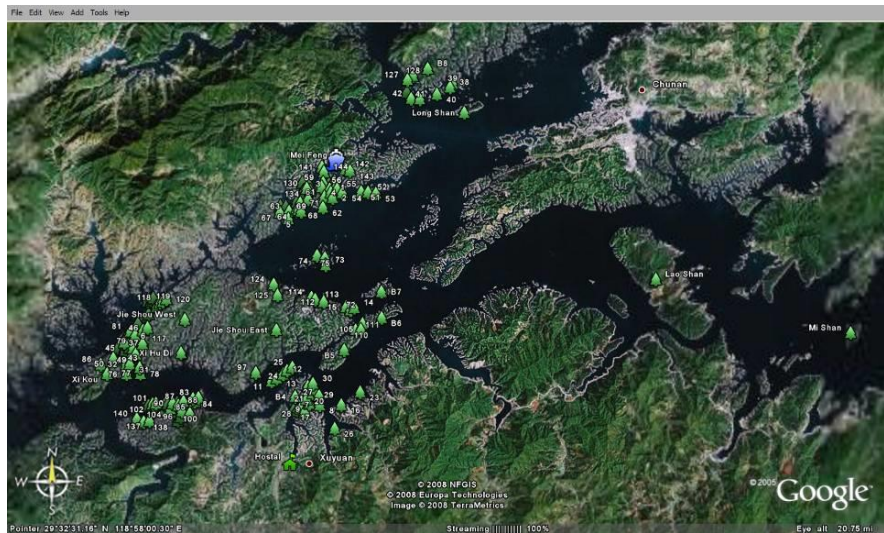


14号样岛





- 32个岛：红外相机调查兽类和地栖鸟类
- 植物丰富度156个岛
- 兽类33个岛
- 蜥蜴42个岛
- 蛇类48个岛
- 两栖类17个岛
- 蜘蛛与地表甲虫31个岛
- 蚂蚁33个岛
- 传粉昆虫41岛

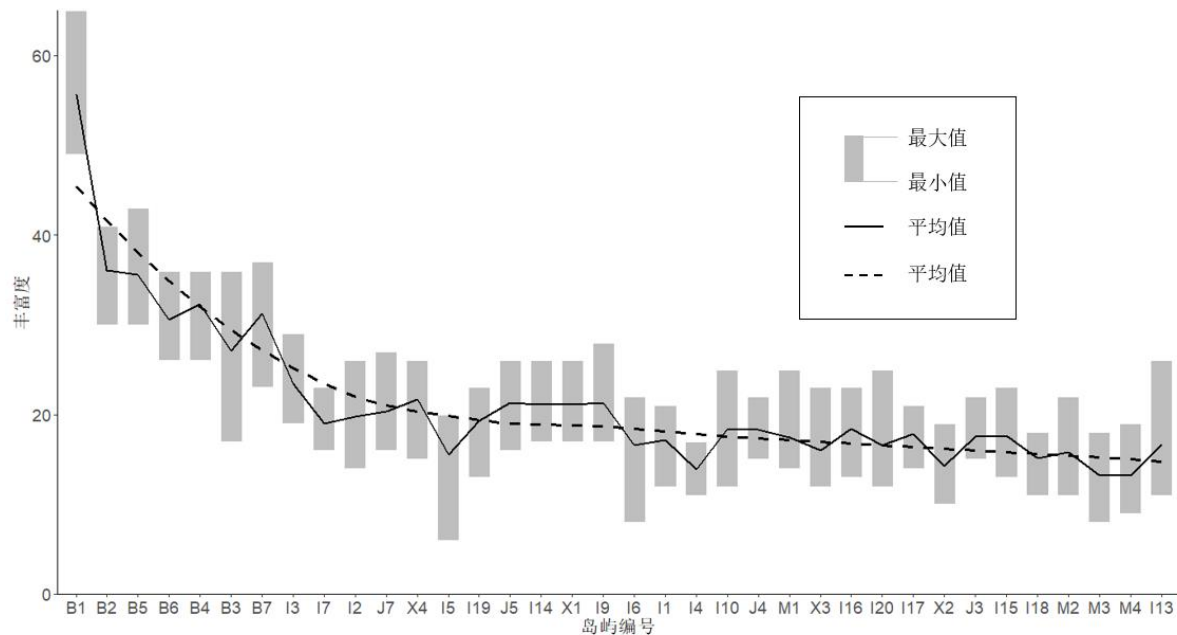


监测结果

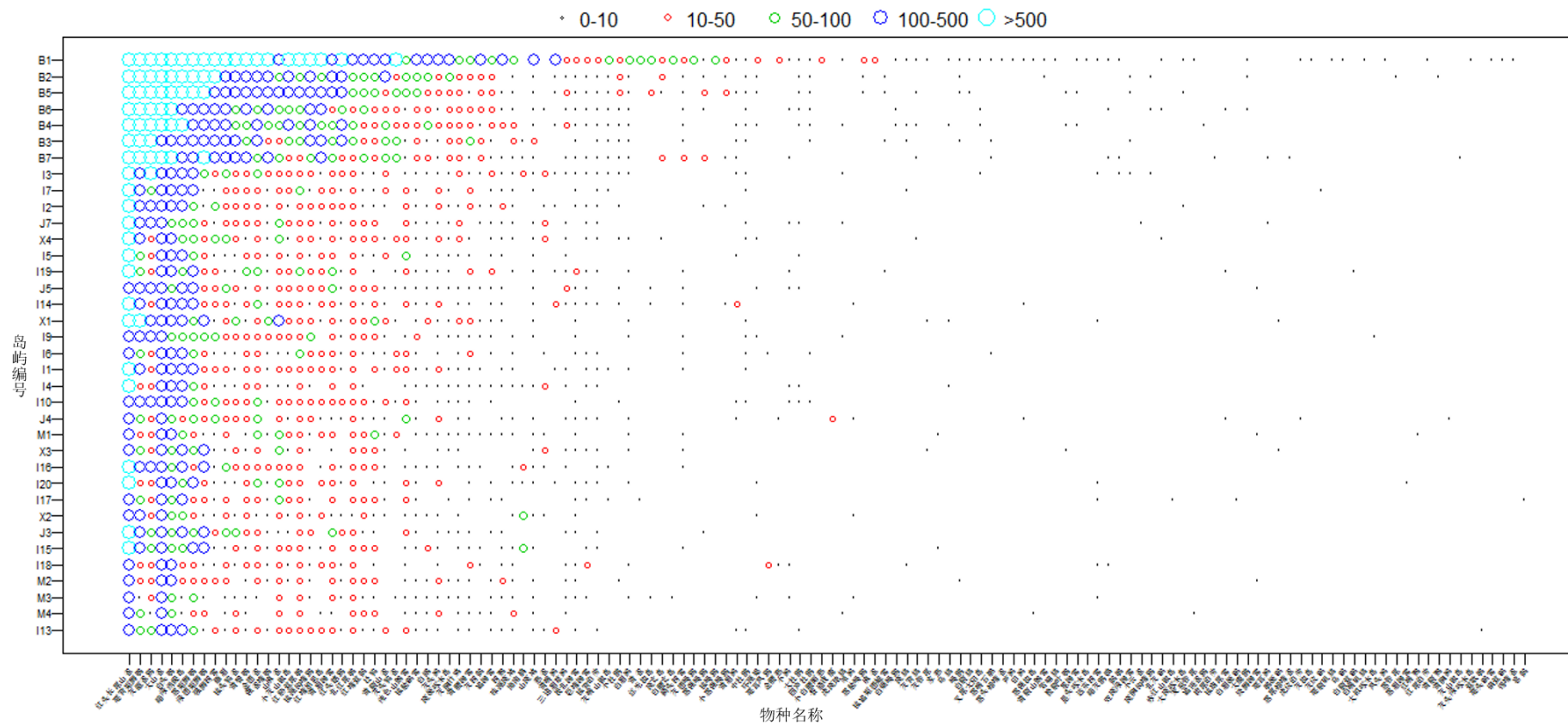
- ❑ 植物：800多种
 - ❑ 两栖类：9种
 - ❑ 爬行类：16种(蜥蜴5种、蛇类11种)
 - ❑ 鸟类：177种
 - ❑ 兽类：20种（小型兽类11种）
 - ❑ 蜘蛛：135种
 - ❑ 蚂蚁：97种
 - ❑ 访花昆虫：290种
-

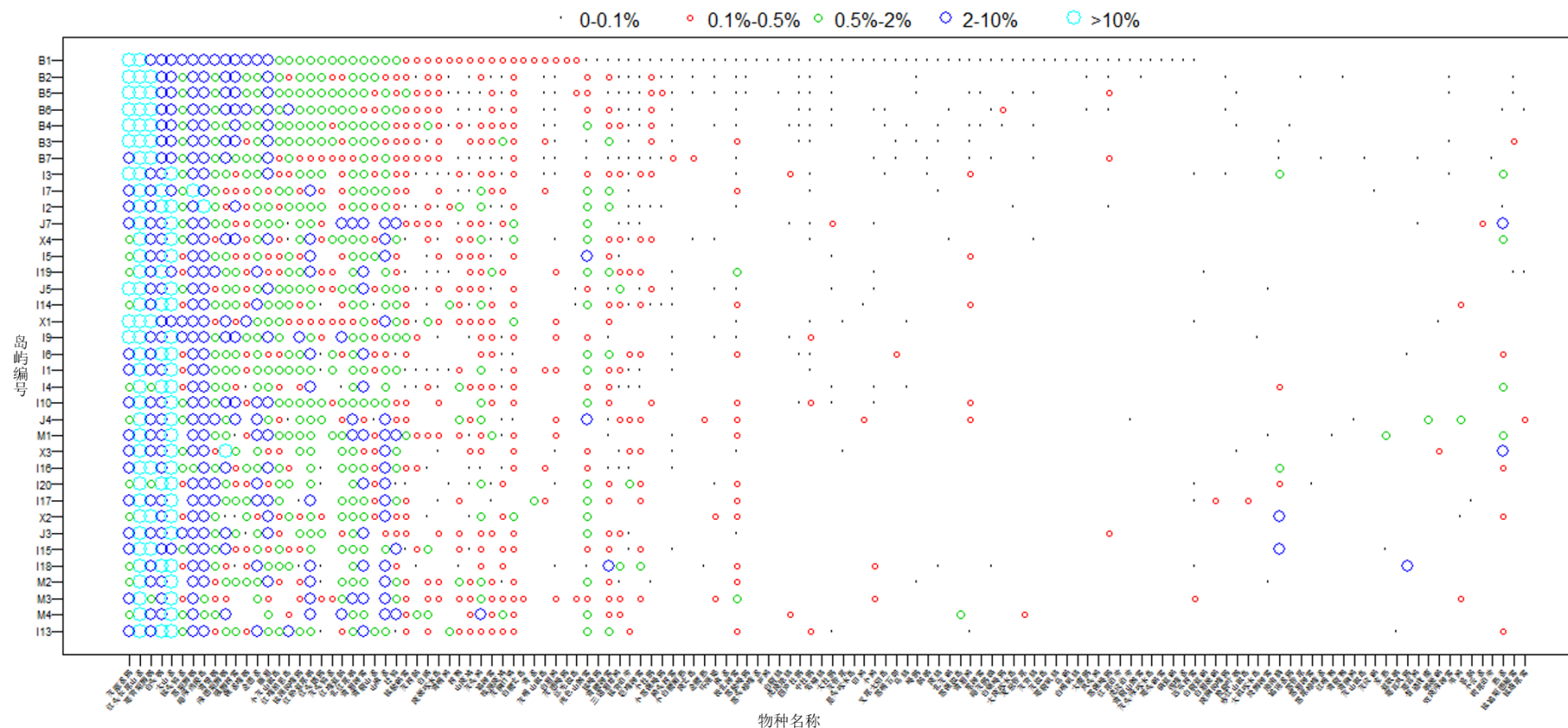


2007-2016年36个岛屿鸟类调查结果



各岛屿物种丰富度(2007-2016)

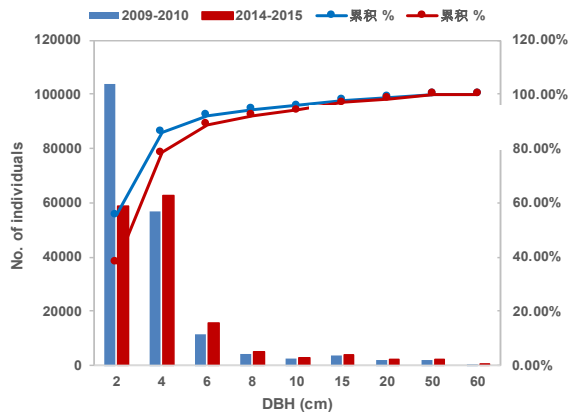
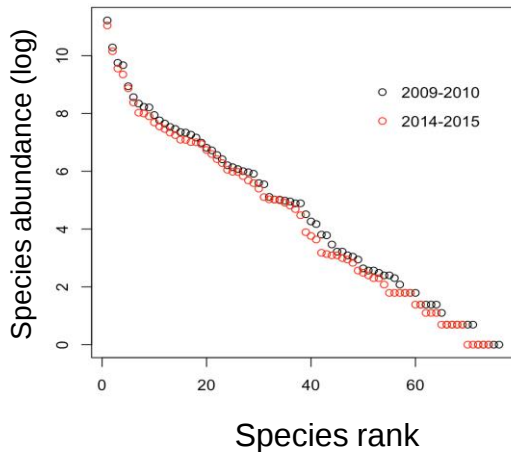




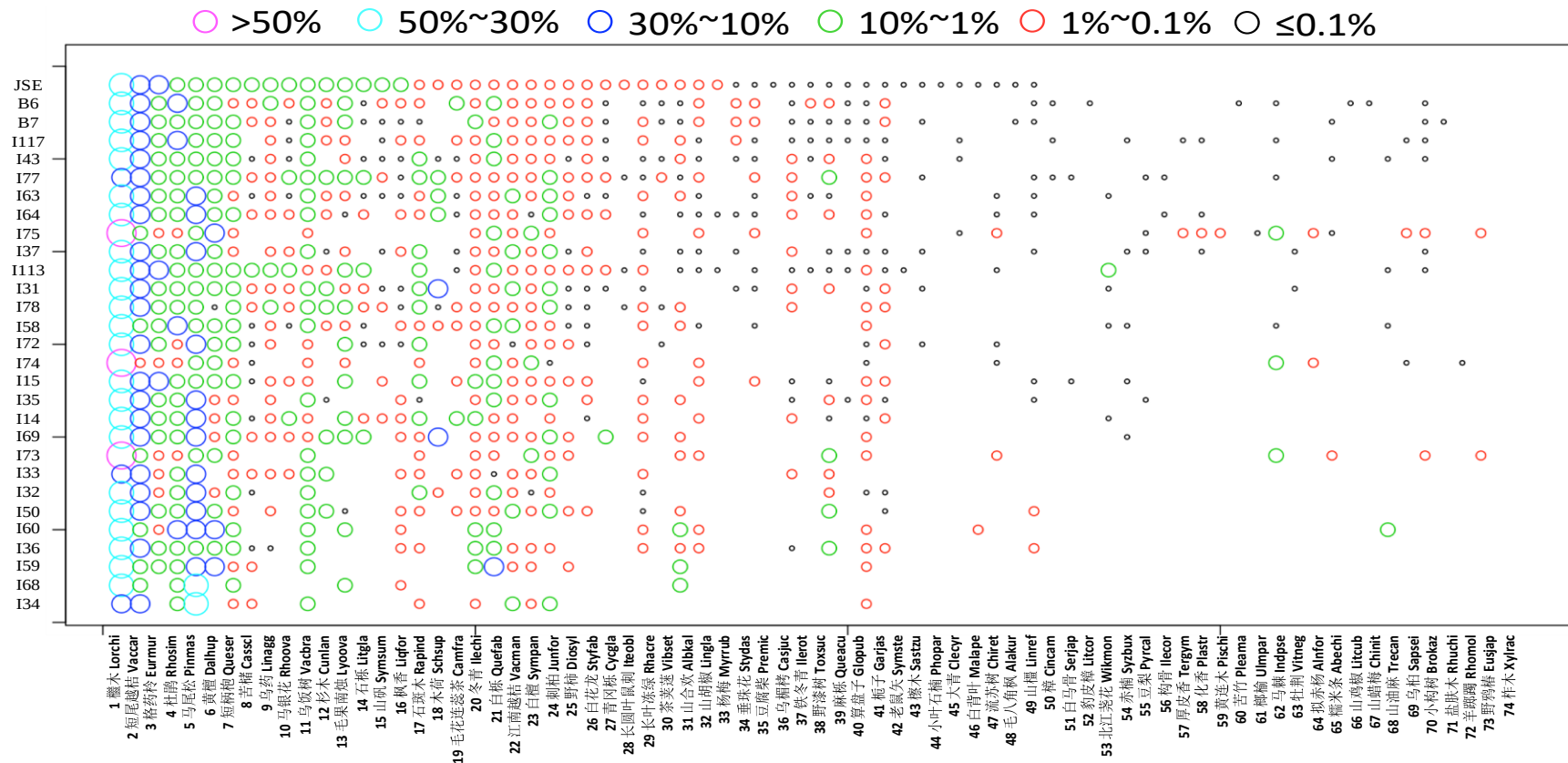
各岛屿鸟类物种相对多度(2007-2016)

29个植物样岛调查结果

第一次调查：
总面积12.7 ha,
78种木本植物
个体数186,842
密度~1.5 株/m²



四个优势种 (榿木 *Loropetalum chinense*, 短尾越桔 *Vaccinium carlesii*, 马尾松 *Pinus massoniana*, 映山红 *Rhododendron simsii*) 占据 > 70% 的个体。49 个物种的个体数 < 0.1%。



29个样岛（按面积大小排序）上每个物种的相对多度

29 个植物样岛5年动态

	物种数	个体数	死亡数	新增数
2009-2010	76	186781		
2014-2015	74	154962	33125	1306

4 成果与案例

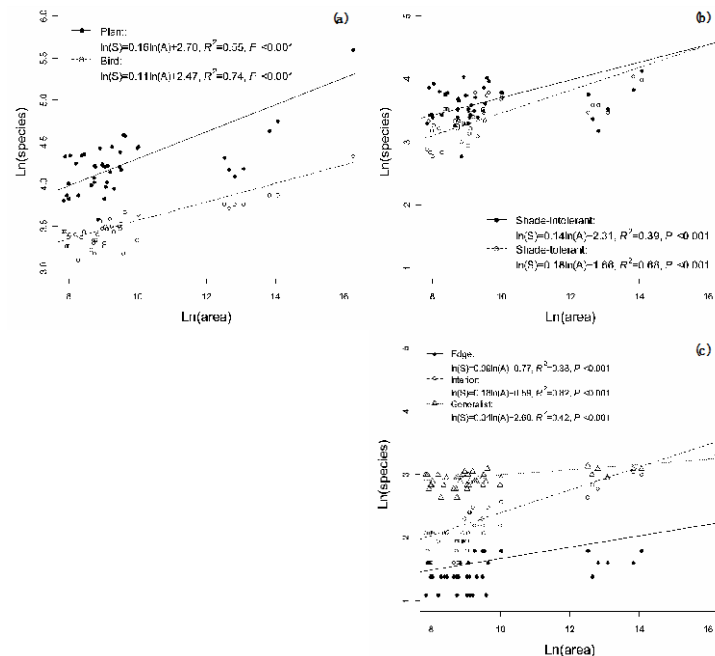
□ 国内外学术刊物发表论文近60篇

□ 国际生态学重要学术刊物论文23篇

- *Biological Reviews* (1)
 - *Ecology* (1)
 - *Journal of Ecology* (3)
 - *Journal of Animal Ecology* (3)
 - *Global Ecology and Biogeography* (1)
 - *Journal of Biogeography* (8)
 - *Landscape Ecology* (3)
 - *Biological Conservation* (1)
 - *Diversity and Distributions* (1)
 - *Oikos* (1)
-

Case 1:群落种-面积关系

- 千岛湖岛屿植物和鸟类
- 存在种-面积关系
- 不同类型的物种对片段化的响应存在差异



Journal of Biogeography (J. Biogeogr.) (2012) 39, 1124–1133

ORIGINAL
ARTICLE



Richness and composition of plants and birds on land-bridge islands: effects of island attributes and differential responses of species groups

Mingjian Yu¹, Guang Hu¹, Kenneth J. Feeley², Jianguo Wu³ and Ping Ding^{1*}

- 岛屿上植物物种多样性的受环境因子如土壤总磷、土层厚度和土壤容重显著影响
- 岛屿种-面积关系中环境过滤的作用不可被忽视

Received: 14 May 2019 | Accepted: 8 August 2019
DOI: 10.1111/1365-2745.13272

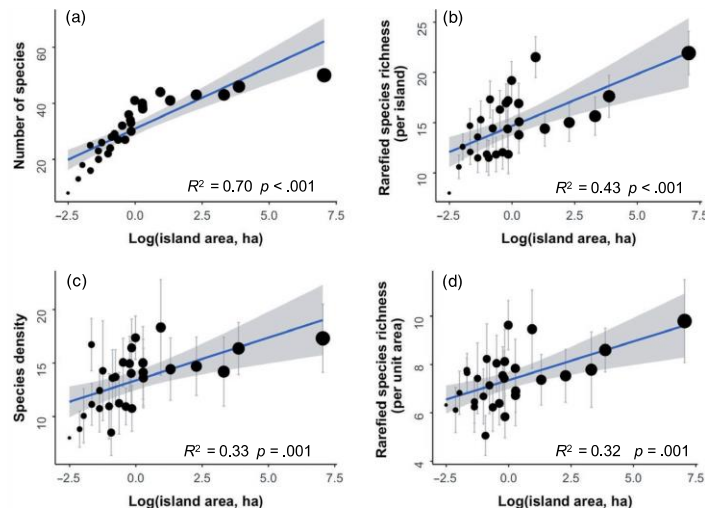
RESEARCH ARTICLE

Journal of Ecology

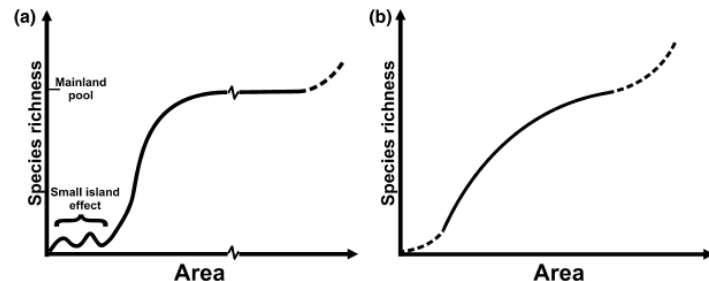


Environmental filtering underpins the island species–area relationship in a subtropical anthropogenic archipelago

Jinliang Liu^{1,2} | Thomas J. Matthews^{3,4} | Lei Zhong¹ | Jijia Liu¹ | Donghao Wu¹ | Mingjian Yu¹



- 种-面积关系小岛屿效应
- 鸟类不存在小岛屿效应
- 两栖类、蛇类存在小岛屿效应
- 小岛屿效应检验必须包含空岛



Oikos 090: 081–098, 2012
doi: 10.1111/j.1600-0706.2012.20322.x
© 2012 The Authors. Oikos © 2012 Nordic Society Oikos
Subject Editor: Rupal S. Etienne. Accepted 13 February 2012

No evidence for the small-island effect in avian communities on islands of an inundated lake

Yanping Wang, Meng Zhang, Siyu Wang, Zhifeng Ding, Jingcheng Zhang, Jiji Sun, Peng Li and Ping Ding

Y. Wang, M. Zhang, S. Wang, Z. Ding, J. Zhang, J. Sun, P. Li and P. Ding (dingping@zjhu.edu.cn), The Key Laboratory of Conservation Biology for Endangered Wildlife of the Ministry of Education, College of Life Sciences, Zhejiang University, CN-310058 Hangzhou, PR China.

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2016) 25, 1333–1345

RESEARCH
PAPER

On empty islands and the small-island effect

Yanping Wang^{1*}, Virginie Millien² and Ping Ding^{1*}

Current Zoology, 2017, 1–7
doi: 10.1093/cz/czx038
Advance Access Publication Date: 20 June 2017
Article

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Basic and Applied Ecology 16 (2015) 10–27

Basic and
Applied Ecology

www.elsevier.com/locate/bae



Macroecology

Article

The small-island effect in amphibian assemblages on sub-tropical land-bridge islands of an inundated lake

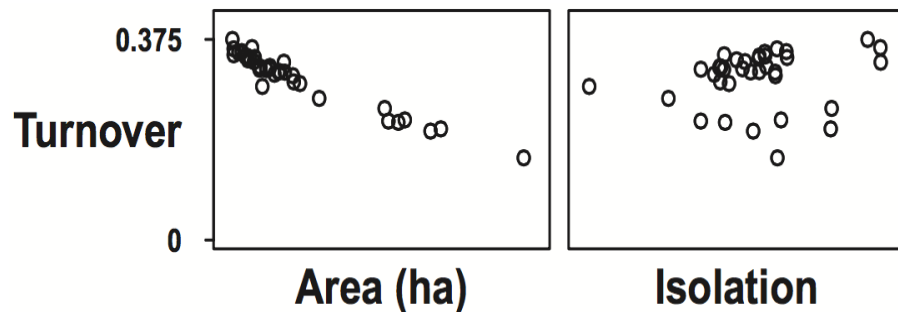
Yanping Wang^{a,*}, Xi Wang^a, Qiang Wu^{a,b,c}, Cangsong Chen^d, Aichun Xu^a, and Ping Ding^a

Small-island effect in snake communities on islands of an inundated lake: The need to include zeroes

Yanping Wang^a, Qiang Wu^a, Xi Wang^a, Chao Liu^a, Lingling Wu^a, Chuanwu Chen^a, Dapeng Ge^a, Xiao Song^a, Cangsong Chen^{a,b}, Aichun Xu^{a,c}, Ping Ding^{a,*}

□ 鸟类物种多样性的稳定性

● 高物种周转率: 30.5%



1–10% year⁻¹ (Schoener 1983 *Oikos*)

Journal of Biogeography (J. Biogeogr.) (2014)

ORIGINAL
ARTICLE

Turnover of breeding bird communities on islands in an inundated lake

Xingfeng Si¹, Stuart L. Pimm², Gareth J. Russell³ and Ping Ding^{1,*}

□ 种-面积-时间关系(SATR)

- 存在着种-面积关系
- 存在着种-时间关系

DOI: 10.1111/jbi.13146

ORIGINAL ARTICLE

WILEY

Journal of
Biogeography

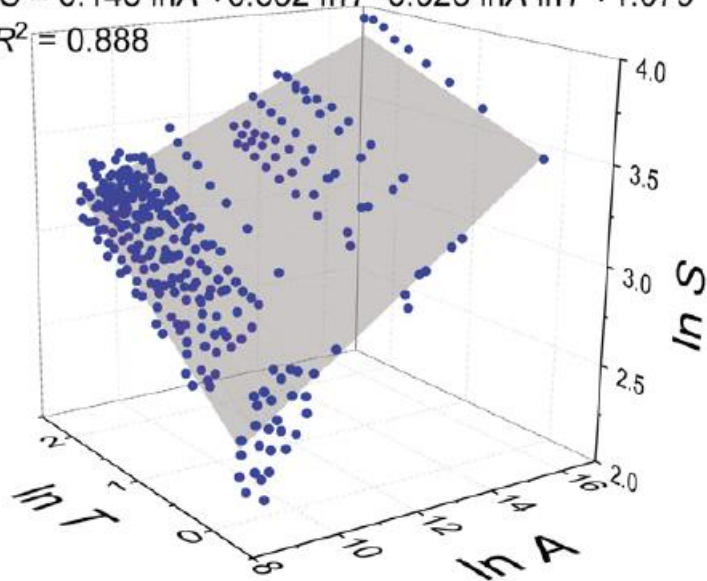
When the species–time–area relationship meets island biogeography: Diversity patterns of avian communities over time and space in a subtropical archipelago

Xiao Song¹ | Robert D. Holt² | Xingfeng Si^{1,3} | Mary C. Christman^{2,4} | Ping Ding¹

(e)

$$\ln S = 0.148 \ln A + 0.632 \ln T - 0.028 \ln A \ln T + 1.079$$

$$R^2 = 0.888$$



Case 2: 功能和谱系多样性

□ 鸟类群落功能多样性

● Fric随岛屿面积增加而增加

● Feve随岛屿面积增加而减小

Journal of Animal Ecology



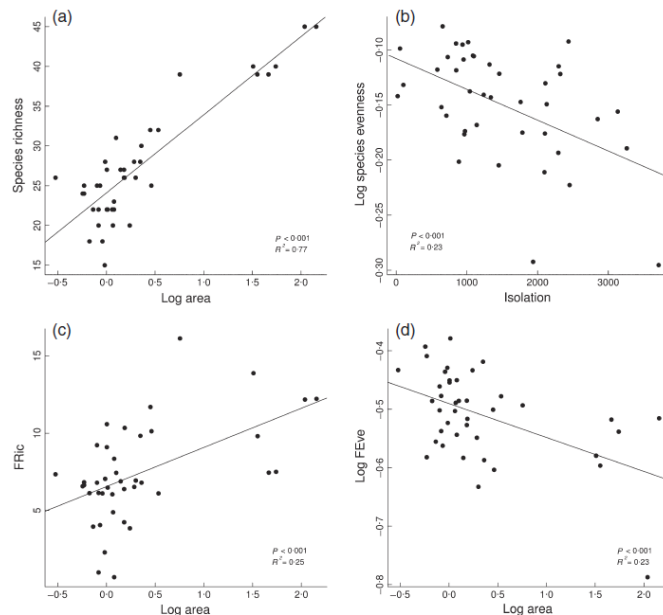
Journal of Animal Ecology 2013, 82, 781–790

doi: 10.1111/1365-2656.12046

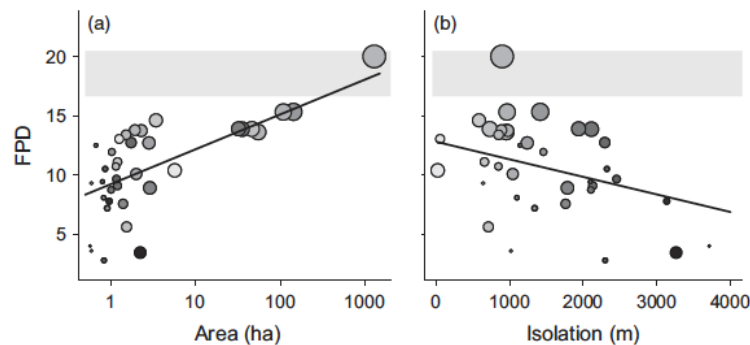
Patterns of bird functional diversity on land-bridge island fragments

Zhifeng Ding¹, Kenneth J. Feeley^{2,3}, Yanping Wang¹, Robin J. Pakeman⁴ and Ping Ding^{1*}

¹The Key Laboratory of Conservation Biology for Endangered Wildlife of the Ministry of Education, College of Life Sciences, Zhejiang University, Hangzhou, China; ²Department of Biological Sciences, Florida International University, Miami, FL, USA; ³Center for Tropical Plant Conservation, Fairchild Tropical Botanic Garden, Coral Gables, FL, USA; and ⁴The James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, UK



- 鸟类功能-谱系多样性随岛屿面积而增加，随岛屿隔离度而下降
- 岛屿鸟类群落在功能和谱系水平上均呈聚集格局，在小而隔离岛屿上更为明显
- 群落构建因素：生境过滤



Journal of Animal Ecology

Journal of Animal Ecology 2017, 86, 532–542



doi: 10.1111/1365-2656.12650

Functional and phylogenetic structure of island bird communities

Xingfeng Si^{1,2}, Marc W. Cadotte^{2,3}, Di Zeng¹, Andrés Baselga⁴, Yuhao Zhao¹, Jiaqi Li¹, Yiru Wu¹, Siyu Wang⁵ and Ping Ding^{*1}

非充分检测对功能和谱系结构计算的影响

- 没有记录到的物种
- 确实没有，或者有而没有记录到
- 多物种占有模型评估
- 非充分检测使物种、功能和谱系多样性被明显低估，其中估算物种多样性时偏差最大

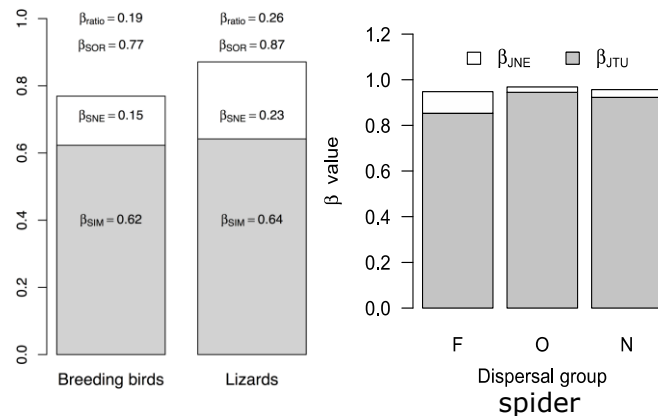
Ecology, 99(9), 2018, pp. 2103–2112
© 2018 by the Ecological Society of America

The importance of accounting for imperfect detection when estimating functional and phylogenetic community structure

XINGFENG SI,^{1,2} MARC W. CADOTTE,^{2,3} YUHAO ZHAO,¹ HAONAN ZHOU,¹ DI ZENG,¹ JIAQI LI,¹ TINGHAO JIN,¹ PENG REN,¹ YANPING WANG,¹ PING DING,^{1,5} AND MORGAN W. TINGLEY⁴

Case 3: β 多样性

- 鸟类、蜥蜴、蜘蛛具高 β 多样性
- 主要受空间周转组分影响
- 鸟类 β 多样性存在季节格局
- β 多样性：冬季留鸟>夏季留鸟
- 嵌套组分：冬季留鸟>夏季留鸟



ORIGINAL ARTICLE

WILEY *Journal of Biogeography*

Do seasonal species assemblages differ in their biogeography? Evidence from the spatial structure of bird communities on land-bridge islands

Chuanwu Chen¹ | Marcel Holyoak² | Xingfeng Si^{1,3} | Yanning Wang¹ | Ping Ding¹

Journal of Biogeography (J. Biogeogr.) (2017) 44, 2121–2131

ORIGINAL ARTICLE

Dispersal modality determines the relative partitioning of beta diversity in spider assemblages on subtropical land-bridge islands

Lingbing Wu^{1†}, Xingfeng Si^{1†}, Raphael K. Didham^{2,3}, Dapeng Ge¹ and Ping Ding^{1*}

PLOS ONE

RESEARCH ARTICLE

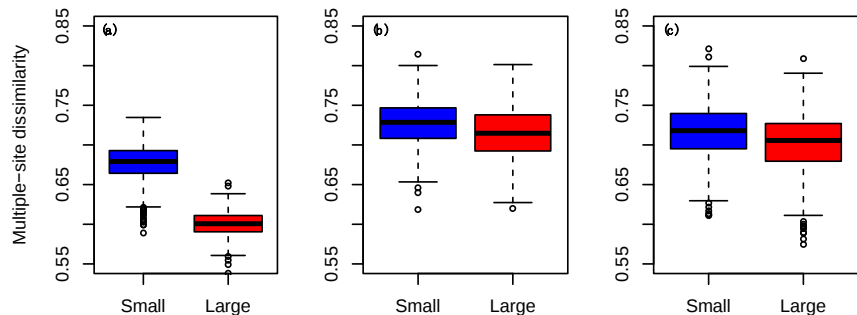
Revealing Beta-Diversity Patterns of Breeding Bird and Lizard Communities on Inundated Land-Bridge Islands by Separating the Turnover and Nestedness Components

Xingfeng Si¹, Andrés Baselga², Ping Ding^{1*}

□ 植物群落 β 多样性

● 小岛屿间比大岛屿间具有更高的 β 多样性

● 主因：生境异质性



DOI:10.1111/jbi.13404

RESEARCH PAPER

WILEY

Journal of
Biogeography

High beta diversity among small islands is due to environmental heterogeneity rather than ecological drift

Jinliang Liu¹ | Mark Vellend² | Zuhua Wang¹ | Mingjian Yu¹



□ 鸟类群落物种和功能 α 与 β 多样性

- 物种周转是物种 β 多样性的主要组分
- 功能嵌套组分在功能 β 多样性中占主导地位
- 选择性灭绝过程导致了物种和功能 β 多样性之间的显著相关性

Journal of Animal Ecology



Journal of Animal Ecology 2016, 85, 409–418

doi: 10.1111/1365-2656.12478

Selective extinction drives taxonomic and functional
alpha and beta diversities in island bird assemblages

Xingfeng Si¹, Andrés Baselga², Fabien Leprieux³, Xiao Song¹ and Ping Ding^{1*}

Case 4: 群落嵌套格局

- 存在嵌套格局的类群
 - 鸟类、蜥蜴类、蛇类和兽类、植物
- 嵌套格局形成驱动力各异
 - 鸟类：选择性灭绝和生境嵌套
 - 蜥蜴类：生境嵌套
 - 蛇类：选择性灭绝、生境嵌套
 - 小型兽类：选择性灭绝、生境嵌套
 - 非鼠类的地栖兽类：选择性灭绝

Landscape Ecol (2011) 26:1405–1417
DOI 10.1007/s10980-011-9662-7

RESEARCH ARTICLE

Determinants of plant species richness and patterns of nestedness in fragmented landscapes: evidence from land-bridge islands

Guang Hu · Kenneth J. Feeley · Jianguo Wu ·
Gaofu Xu · Mingjian Yu

Current Zoology 58 (6): 828–836, 2012

Nestedness of snake assemblages on islands of an inundated lake

Yanping WANG, Xi WANG, Ping DING*

Diversity and Distributions, (Diversity Distrib.) (2010) 16, 862–873

Biogeography



Nestedness for different reasons: the distributions of birds, lizards and small mammals on islands of an inundated lake

Yanping Wang¹, Yixin Bao², Mingjian Yu¹, Gaofu Xu³ and Ping Ding^{1*}

Journal of Biogeography (J. Biogeogr.) (2011) 38, 1330–1344

ORIGINAL ARTICLE



Testing multiple assembly rule models in avian communities on islands of an inundated lake, Zhejiang Province, China

Yanping Wang¹, Shuihua Chen² and Ping Ding^{1*}

Case 5: 群落更新

- 小岛上森林群落以演替早期种为主，动物传播和耐阴种较少
- 小岛具有和大岛上相似的单位面积地上生物量，主要归因于快速生长的优势种马尾松的贡献
- 岛屿面积是次生演替的关键因素，隔离度的作用相对较小
- 边缘效应影响物种和功能组成

ECOLOGICAL SUCCESSION IN A CHANGING WORLD

Journal of Ecology 

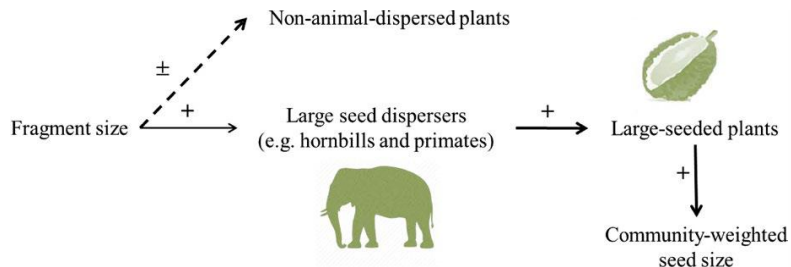
Larger fragments have more late-successional species of woody plants than smaller fragments after 50 years of secondary succession

Jiajia Liu^{1,2}  | David A. Coomes² | Guang Hu³ | Jinliang Liu¹ | Jingjing Yu⁴ | Yangqing Luo¹ | Mingjian Yu¹ 

Case 6: 种间互作

□ 种子扩散者-种子-植物群落

- 鸟类传播的种子比兽类传播的种子小
- 鸟类为主要传播者
- 导致大岛上富集更多的小种子植物



ORIGINAL RESEARCH PAPER

DOI:10.1111/j.1365-2745.2014.02988.x

RESEARCH PAPER

WILEY

Journal of
Biogeography

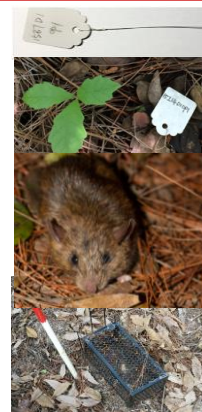


The distribution of plants and seed dispersers in response to habitat fragmentation in an artificial island archipelago

Jia Jia Li^{1,2} | Ferry Slik³ | David A. Coomes² | Richard T. Corlett⁴ |
Yanping Wang⁵ | Maxwell Wilson⁶ | Guang Hu⁷ | Ping Ding¹ | Ming'an Yu¹

鼠类-短柄枹种子扩散系统

- 片段化会导致大型兽类丧失产生营养级效应
- 面积通过影响大型兽类丧失和鼠类对种子资源的竞争强度间接地促进鼠类对植物种子的传播
- 隔离度直接限制鼠类对植物种子的传播



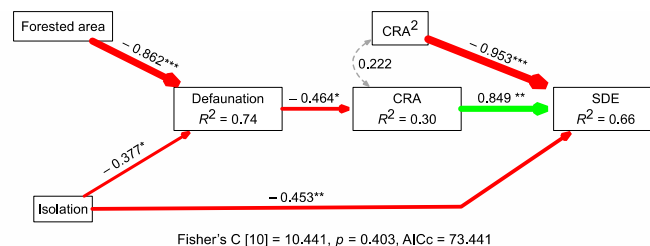
RESEARCH ARTICLE

Journal of Ecology



Cascading effects of forested area and isolation on seed dispersal effectiveness of rodents on subtropical islands

Di Zeng¹ | Robert K. Swihart² | Yuhao Zhao¹ | Xingfeng Si^{1,3} | Ping Ding¹



成果的项目支撑：本团队承担的研究项目

- 国家自然科学基金21项
 - 重点项目1项
 - 中美生物多样性领域合作研究项目1项
 - 重大国际(地区)合作研究项目1项
 - 面上项目10项、青年项目8项
- 国家重点研发计划政府间合作专项1项
- 省自然科学基金3项
 - 杰出青年基金项目1项
 - 重点项目和重大项目各1项



□ 国家自然科学基金

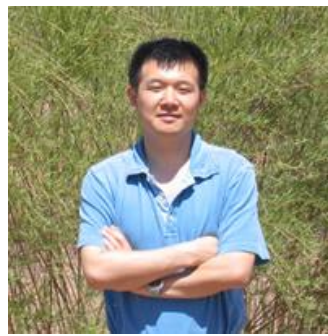
- 重点项目：片段化生境中植物群落物种共存和多样性维持机制-基于多营养级相互作用的研究（于明坚 2020-2024）
- 中美生物多样性领域合作研究项目：片段化景观中谱系、功能、遗传多样性与生态系统功能研究（于明坚 2014-2018）



西澳大学
Raphael K. Didham教授



邬建国教授



蒋林教授

亚利桑那州立大学 佐治亚理工学院

- 重大国际合作研究项目：亚热带片段化生境中食物网结构及其对鸟类和植物群落的影响-以千岛湖陆桥岛屿研究为例（丁平 2013-2017）
- 科技部国家重点研发计划政府间国际科技创新合作专项：松材线虫入侵后马尾松林生态系统服务功能变化及提升技术研究示范（于明坚 2020-2022）



Dr. Kenneth
Feeley



Dr. Scott K.
Robinson



5 国际关注与影响

- 加拿大University of Alberta大学何芳良教授
- 美国亚利桑那大学Michael L. Rosenzweig教授
- 加拿大皇家学会会员、蒙特利尔大学Pierre Legendre教授



- 美国Duke University的John W. Terborgh院士和Lisa C. Davenport博士
- 美国Duke University的Stuart L. Pimm教授(美国文理科学院院士)
- 美国University of Florida的Pamela S. Soltis院士



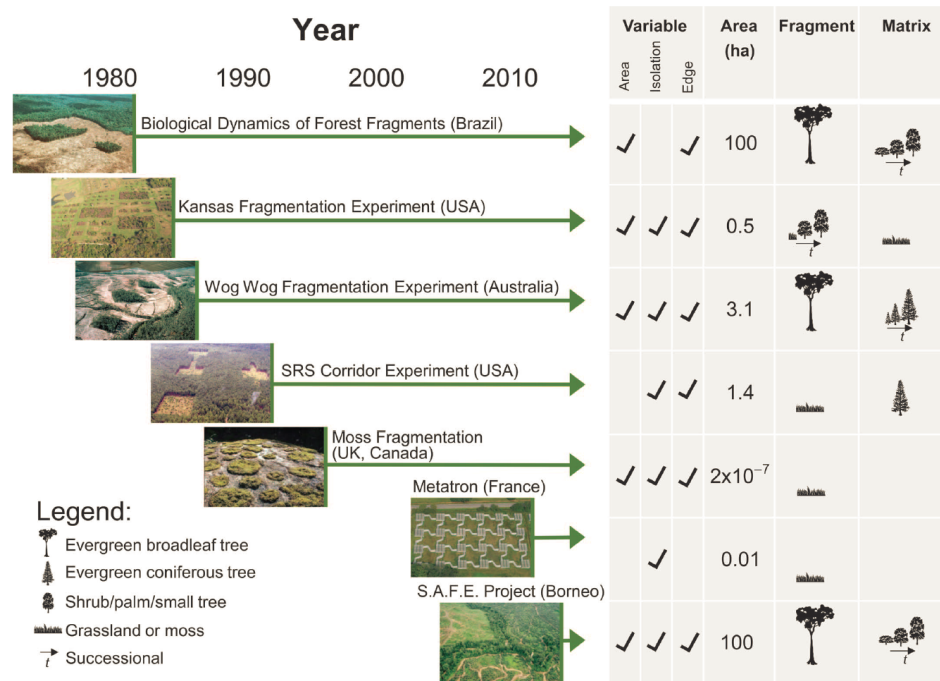
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2015年千岛湖生境片段化与生物多样性保护国际研讨会

全球正在实施的重要 片段化长期研究平台



- 第8个片段化重要长期研究平台
- 空间尺度最大的实验研究平台

Landscape Ecol (2016) 31:219–227
DOI 10.1007/s10980-015-0312-3



EDITORIAL

Habitat fragmentation and biodiversity conservation: key findings and future challenges

Maxwell C. Wilson · Xiao-Yong Chen · Richard T. Corlett ·
Raphael K. Didham · Ping Ding · Robert D. Holt · Marcel Holyoak ·
Guang Hu · Alice C. Hughes · Lin Jiang · William F. Laurance ·
Jiajia Liu · Stuart L. Pimm · Scott K. Robinson · Sabrina E. Russo ·
Xingfeng Si · David S. Wilcove · Jianguo Wu · Mingjian Yu



其它7个平台中最大的为100ha

□ 全球唯一长期定位研究的人工陆桥岛屿研究的重要平台



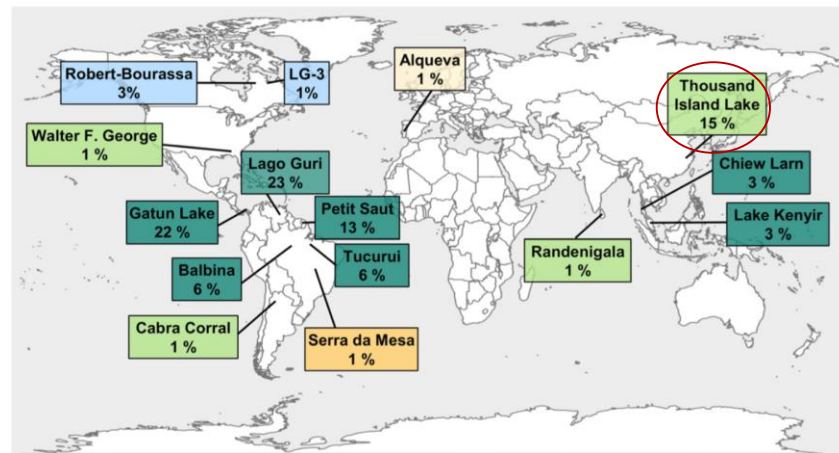
Extinction debt on reservoir land-bridge islands

Isabel L. Jones^{a,*}, Nils Bunnefeld^a, Alistair S. Jump^a, Carlos A. Peres^b, Daisy H. Dent^{a,c}

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Contributors:

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Forestry Bureau of Chun'an County

Funding agencies:



A scenic sunset over a lake with mountains in the background. The sky is filled with soft, orange and yellow clouds, and the sun is low on the horizon, casting a warm glow. The water in the foreground is dark and calm, reflecting the light from the sky. The mountains in the background are silhouetted against the bright sky.

谢 谢!

真诚地邀请您，并欢迎您加入我们的研究团队!