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封面图说: 白洋淀是华北地区最大的淡水湖泊湿地。淀区内沟壕纵横交织错落,村庄、苇地、园田星罗棋布,在水文、水化学、生物地球化学循环以及生物多样性等方面,具有非常复杂的异质性。随着上游城镇污废水、农田径流进入水域,淀区富营养化日益加剧。复杂的水环境特点、高度的景观异质性和良好的生物多样性,使得该地区成为探索规模性厌氧氨氧化反应的良好研究地点(详见本期第 6591—6598 页)。

彩图提供:王为东博士 中国科学院生态环境研究中心 E-mail: wdwangh@yahoo.com

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村落文化林与非文化林多尺度物种多样性加性分配

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摘要:文化林是指村民按照文化传统、风俗习惯或宗教信仰自觉保护和管理的森林,具有一定社会文化功能。目前国内外对文化林物种多样性研究主要为定性描述,缺乏对文化林和非文化林生物多样性的定量比较及差异来源分析。利用物种多样性加性分配方法,将总的 Gamma 多样性分成样格内的 Alpha 多样性以及样格间、样方间和林型间 Beta 多样性,对中国亚热带地区 3 个村落文化林的乔木层、灌木层、草本层和藤本层进行物种多样性的多尺度分析。调查发现:(1)文化林共有维管束植物 296 种,以苦槠、樟和米槠为优势种,非文化林共有维管束植物 189 种,以杉木、马尾松和毛竹为优势种。文化林乔木层和灌木层物种数显著高于非文化林,草本层和藤本层物种数差异不显著。(2)Beta 多样性随尺度增大而增加,林型间 Beta 多样性最高,占区域总 Gamma 多样性的 41.9%—62.8%,其次是样方间 Beta 多样性(18.6%—31.9%),对区域多样性贡献最小为样格内 Alpha 和样格间 Beta 多样性。(3)林型间的多样性对区域物种多样性的贡献中,文化林占主导作用,乔木层占 54.4%—81.0%,灌木层占 51.2%—60.2%,草本层占 42.9%—64.1%,藤本层占 49.9%—62.2%。(4)物种累积-面积曲线表明,在各个尺度上,文化林物种多样性始终高于非文化林,从而在相同面积下保护了更多的物种。加性分配模型在多个空间尺度上阐明了 Alpha 和 Beta 多样性的变化,突出了文化林对区域物种多样性的贡献,对保护对象和保护范围的决策以及生物多样性的保护与恢复具有重要意义。

关键词:文化林; 物种多样性; 加性分配; Beta 多样性

Additive partition of species diversity across multiple spatial scales in community culturally protected forests and non-culturally protected forests

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Abstract: Culturally protected forests, which are preserved and managed by local people on the basis of traditional cultural practices and beliefs, have certain social and ecological functions, and also show significant role in biodiversity conservation. The research worldwide nowadays mainly focuses on qualitative description of culturally protected forests and therefore lack quantitative comparison of biodiversity and difference in species composition between culturally protected forests and non-culturally protected forests, particularly diversity from different spatial scales. The tree layer, shrub layer, herb layer and vine layer of three culturally protected forests and non-culturally protected forests were investigated, using additive partition measured by species abundance to analyze diversity of multi-scale in subtropical region of China. Partitioning of total species diversity can be described as Alpha diversity (within grid diversity) + Beta diversity = Gamma diversity (total diversity at landscape), among which Beta diversity could be divided into diversity between grids, diversity between plots, diversity between forest types. The results were: (1) Total 296 species belonging to 66 families and 163 genera were found in culturally protected forests, dominated by *Castanopsis sclerophylla*, *Cinnamomum camphora* and

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Castanopsis carlesii, while 189 species belonging to 67 families and 135 genera were found in non-culturally protected forests, dominated by *Cunninghamia lanceolata*, *Pinus massoniana* and *Phyllostachys heterocycla* cv. *pubescens*. Culturally protected forests had more species in tree layer and shrub layer although the differences of species composition were complex in herb and vine layer depending on human disturbance and locations, and most of species diversity was higher in culturally protected forests. (2) This model implied that Beta diversity was increasing at larger spatial scale, and which showed uniform results in different layers in both culturally protected forests and non-culturally protected forests. Additive partitioning of diversity between forest types was highest which was from 41.9% to 62.8% of total diversity at landscape level, followed by diversity between plots which was from 18.6% to 31.9%, the contribution of diversity within and between grids was only small proportion. (3) Culturally protected forests play dominant role in partitioning of diversity between forests types, and provided 54.4% to 81.0%, 51.2% to 60.2%, 42.9% to 64.1%, 49.9% to 62.2% of total diversity in culturally protected forests and non-culturally protected forests in tree, shrub, herb and vine layers respectively. That means culturally protected forests act as species pool to the regional area, particularly in conservation of tree species. (4) Species accumulation curves of tree layer achieved smooth slower indicating larger number stands protected in culturally protected forests than non-culturally protected forests within the same sample area. Additive partitioning of species diversity offers an operational method for explaining species diversity and in terms of better understanding of how alpha and Beta diversity change across multiple spatial scales. The model suggests culturally protected forests could be key factor to make contribution for diversity at landscape level. Therefore, when making biodiversity protection and restoration strategies, it's better to focus more on culturally protected forests. However, the impact of human disturbance to culturally protected forests still needs to be studied in depth.

Key Words: culturally protected forests; species diversity; additive partitioning; Beta diversity

文化林是指村民按照文化传统、风俗习惯或宗教信仰自觉保护和管理的森林,文化林具有一定社会文化功能,多数分布在我国农村地区,被持续保护了几十、几百甚至上千年。很多学者指出,利用文化传统和宗教信仰对生物多样性的保护比仅依靠法规政策的保护可能更有利于可持续发展^[1-4]。国外学者对文化林例如神山,圣地的资源保护功能关注较多^[5-8]。我国学者对文化林的研究以少数民族地区居多,如西南地区少数民族的神山^[9-12]、民族传统文化^[13-15]和传统知识^[16-17]对生物多样性的保护和自然资源的管理,也有研究指出文化林的生物多样性较高^[18-19]。但对文化林群落的分析相对较少,尤其是物种多样性的尺度来源未见报道。

生物多样性与尺度密切相关,利用加性分配方法,即 $\text{Beta} = \text{Gamma} - \text{Alpha}$ ^[20],可以在多个尺度上,将村落周边森林群落总的生物多样性(Gamma)分解为最小取样单元内的 Alpha 多样性,和多个空间尺度和森林类型上的 Beta 多样性。在加性模型中,Alpha、Beta 和 Gamma 多样性的表达方式相同,单位相同,可以直接进行比较,能跨尺度解释 Alpha 和 Beta 多样性对区域总的 Gamma 多样性的贡献和来源^[21-24]。因此广泛应用于物种多样性在空间尺度上的保护^[25-27],能更好地说明多样性与尺度的关系以及各个不同尺度对多样性保护的影响。

物种累积-面积曲线描述物种数目随取样面积增加而增长的趋势^[28],一般用幂函数进行拟合^[29]。物种-面积关系的尺度效应以及区域差异对生物多样性估算和评价具有重要价值,如群落类型、物种类群和土地利用方式都会影响物种累积——面积曲线^[30-31]。这样,就可以根据物种数目随面积增加而增长的速率,在各个空间尺度上评价文化林和非文化林的物种多样性^[32]。

本研究以我国南方 3 个村落文化林为研究对象,与周围面积最大最典型的森林类型作为非文化林进行比较,在进行系统取样后,运用生物多样性加性分配模型和物种累积-面积曲线,在多个空间尺度上进行分析:(1)文化林与非文化林物种组成的差异;(2)文化林与非文化林对区域物种多样性的贡献;(3)不同尺度对区域物种多样性的贡献大小。明确文化林在物种保护中的作用,为生物多样性保护范围与目标的确定提供

参考。

1 研究区域与研究方法

1.1 研究区域

本研究调查了福建、江西两省 3 个村落的文化林(表 1)。其中,龙岩市属亚热带海洋性季风气候,上饶市属中亚热带湿润型气候,两地均气候温暖,光照充足,雨量充沛,无霜期长。

表 1 调查区域自然属性
Table 1 Natural attributes of the study area

项目 Item	福建省龙岩市新罗区龙潭村 Fujian Province, Longyan City, Xinluo District, Longtan Village	江西省上饶市婺源县汾水村 Jiangxi Province, Shangrao City, Wuyuan County, Fenshui Village	江西省上饶市婺源县江湾村 Jiangxi Province, Shangrao City, Wuyuan County, Jiangwan Village
纬度 Latitude	N:25°06'11"—25°06'47"	N:29°12'52"—29°13'16"	N:29°21'15"—29°22'50"
经度 Longitude	E:116°55'17"—116°55'48"	E:117°35'57"—117°36'40"	E:118°02'44"—118°03'43"
年均温 Average temperature/℃	18.7—21.0	16.7—18.3	16.7—18.3
年降雨量 Annual precipitation/mm	1031—1369	1600—1800	1600—1800
海拔 Altitude/m	348—490	87—130	128—185
坡度 Slope/(°)	15—40	5—35	8—40

1.2 样方设置

文化林为天然林,干扰轻微,面积从 0.3 hm² 到 9 hm² 不等,均属集体林。在每个村庄的文化林中随机选取 5 个 20 m×20 m 的标准样地,每个标准地内均匀划分 4 个 10 m×10 m 的样格,记录样方中乔木层树木种类、数量、胸径(*DBH*≥3cm)和树高,并记录每个样方中的藤本植物。在每个乔木样格中,随机设置 1 个 5 m×5 m 的小样格,调查灌木(含乔木的更新苗)种类、数量、冠幅和平均高度。同样,随机设置 1 个 1 m×1 m 的小样格,调查其草本的种类、数量和盖度。同时还记录了样地海拔、坡度、坡向、经纬度和干扰程度等。以每个村庄周围最典型面积最大森林类型作为非文化林进行对比,调查方法同上。其中,汾水和龙潭村为天然次生林,而江湾村为人工林,干扰较重。共调查了 120 个 10m×10m 的乔木样格,120 个 5m×5m 的灌木样格,120 个 1m×1m 的草本样格。

1.3 数据分析

1.3.1 重要值计算

用重要值来判定群落中的优势物种,重要值= $(a+b+c)/3$ 。式中 *a* 为相对密度=一个种的密度/所有种的密度×100%;*b* 为相对优势度=某一种的基面积之和/全部种的基面积之和×100%;*c* 为相对频度=一个种的频度/所有种的频度×100%。上述公式中,乔木层相对优势度用胸高断面积计算,灌木层优势度用冠幅来计算,草本层则用盖度计算^[33]。物种丰富度的统计分析采用 SPSS18.0 软件(双因素方差)实现。

1.3.2 生物多样性加性分配模型

本研究用多样性加性分配模型来计算不同层次上的多样性。其中,Alpha 为样格内多样性,Beta 多样性即样格间 Beta 多样性、样方间 Beta 多样性和林型间 Beta 多样性,总的 Gamma 多样性,等于最小尺度的 Alpha 多样性加上每一尺度的 Beta 多样性,即区域物种多样性等于样格内 Alpha 多样性+样格间 Beta 多样性+样方间 Beta 多样性+林型间 Beta 多样性(图 1)。

1.3.3 物种面积累积曲线

为了估算文化林、非文化林以及整个区域的物种数目,本文用面积相同的样格(10m×10m)随机组合,进行

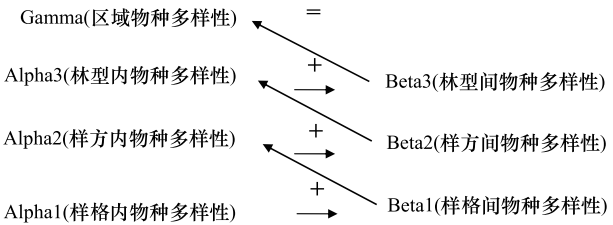


图 1 物种多样性加法分配法则划分不同尺度的物种多样性组分关系

Fig. 1 Schematic representation of the different hierarchical scales according to additive partitioning of biodiversity

物种累加,面积大小从 100 m² 累积到 2000 m²。软件 EstimateS Win8. 20^[34] 实现选择随机样格中物种数目的各种组合,获取样格组系列,得到物种面积累积关系,用幂函数拟合关系最好。

2 结果

2.1 文化林与非文化林的群落结构

文化林群落完整,种类丰富,一般处于演替顶级或后期。三个文化林共有维管束植物 296 种,属于 66 科,163 属,以樟科(Lauraceae, 22 种)、壳斗科(Fagaceae, 16 种)和山茶科(Theaceae, 15 种)为主。非文化林中共有维管束植物 189 种,属于 67 科,135 属,以壳斗科(17 种)、大戟科(Euphorbiaceae, 13 种)、禾本科(Gramineae, 13 种)为主。文化林物种数显著高于非文化林,其中乔木层差异最大($P=0.000$),灌木层、草本层和藤本层无显著差异($P>0.05$)。

文化林乔木层包括了更多的物种,以苦槠(*Castanopsis sclerophylla*)、樟(*Cinnamomum camphora*)和米槠(*Castanopsis carlesii*)为优势种(附录),非文化林则以毛竹(*Phyllostachys carlesii* cv. *pubescens*)、杉木(*Cunninghamia lanceolata*)、马尾松(*Pinus nighamia lan*)为主。在 3 个调查区中,乔木层物种多样性最高为汾水村 48 种,非文化林只有 40 种。其次江湾村 40 种,非文化林 10 种。最低为龙潭村 34 种,非文化林为 27 种。

灌木层物种丰富度,文化林也相对高于非文化林,并以油茶(*Camellia oleifera*)、木荷(*Schima superba*)、紫金牛(*Ardisia superba*)为优势种,非文化林则以苦竹(*Pleioblastus amarus*)、茶(*Camellia sinensis*)为主。灌木层物种多样性,汾水村调查中发现 87 个物种,非文化林有 58 个物种。龙潭村文化林灌木层物种多样性为 75 种,非文化林为 66 种。江湾村文化林灌木层多样性为 58 个物种,非文化林有 57 个物种。

除了龙潭村之外,江湾村和汾水村的草本层物种丰富度也高于非文化林,物种组成上差异较小。文化林草本层共有 29 个物种,非文化林有 16 个物种。龙潭村文化林草本层包含 26 个物种,非文化林有 34 个物种。汾水村的文化林草本层包含 15 个物种,非文化林包含 14 个种。

藤本层多样性龙潭村文化林物种丰富度为 40 种,非文化林为 41 种。江湾村文化林藤本层有 32 种,非文化林有 20 种。汾水村的文化林藤本层有 25 种藤本植物,非文化林只有 19 种。

2.2 不同尺度下文化林与非文化林的加性分配

相对非文化林来说,文化林乔木层对区域乔木层物种多样性的贡献为 54.4%,81.0%,59.0%。从 4 个尺度来看,在 3 个区域的两种林型中,不同尺度对区域物种多样性的贡献,除江湾村非文化林呈现 $\text{Beta}3>\text{Beta}2>\text{Alpha}1>\text{Beta}1$,其余均呈现一致的结果: $\text{Beta}3>\text{Beta}2>\text{Beta}1>\text{Alpha}1$ 。林型间多样性贡献较大,占区域总 Gamma 多样性的 54.6%—62.8%,样方间多样性贡献居其次,占区域总多样性的 18.6%—22.7%(图 2)。

相对非文化林来说,文化林灌木层对区域物种多样性的贡献为 51.2%,53.8%,55.2%。从 4 个尺度来看,在 3 个区域的两种林型中,不同尺度对区域物种多样性贡献,一半呈现 $\text{Beta}3>\text{Beta}2>\text{Beta}1>\text{Alpha}1$,另一半为 $\text{Beta}3>\text{Beta}2>\text{Alpha}1>\text{Beta}1$ 。林型间多样性占区域总多样性的 41.9%—53.9%,样方间多样性占区域总多样性的 23.1%—29.0%(图 3)。

文化林草本层对区域物种多样性的贡献为 64.1%,42.9%,53.2%。从 4 个尺度来看,在 3 个区域的两种林型中,不同尺度对区域物种多样性贡献,江湾村非文化林和汾水村文化林物种多样性贡献为 $\text{Beta}3>\text{Beta}2>\text{Alpha}1>\text{Beta}1$,其余的均为 $\text{Beta}3>\text{Beta}2>\text{Beta}1>\text{Alpha}1$ 。林型间多样性占区域总多样性的 53.2%—56.5%,样方间多样性占区域总多样性的 21.7%—23.4%(图 4)。

文化林藤本层对区域物种多样性的贡献为 62.2%,54.8%,49.9%。从 4 个尺度来看,在 3 个区域的两种林型,不同尺度对区域物种多样性贡献为,江湾村文化林 $\text{Beta}3>\text{Beta}2>\text{Alpha}1>\text{Beta}1$,其余的均为 $\text{Beta}3>\text{Beta}2>\text{Beta}1>\text{Alpha}1$ 。林型间多样性占区域总多样性的 50.8%—57.5%,样方间多样性占区域总多样性的 21.3%—24.6%(图 5)。

2.3 物种累积-面积曲线

通过随机选择面积相同的样格中物种的组合来建立物种数目随面积增加的累计曲线,得到文化林与非文

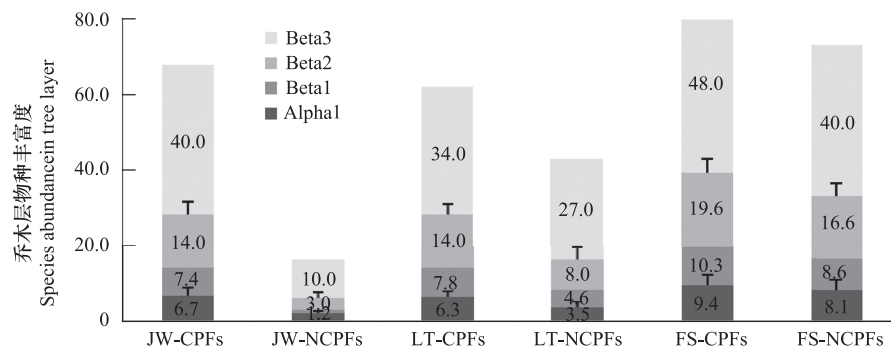


图2 村落文化林与非文化林乔木层物种丰富度的加性分配

Fig. 2 Additive partitioning of species abundance of tree layer in community culturally protected forests and non-culturally protected forests

Alpha: 样格内物种多样性, Beta1: 样格间多物种多样性, Beta2: 样方间物种多样性, Beta3: 林型间物种多样性; LT: 龙潭, FS: 汾水, JW: 江湾, CPFs: 文化林, NCPFs: 非文化林

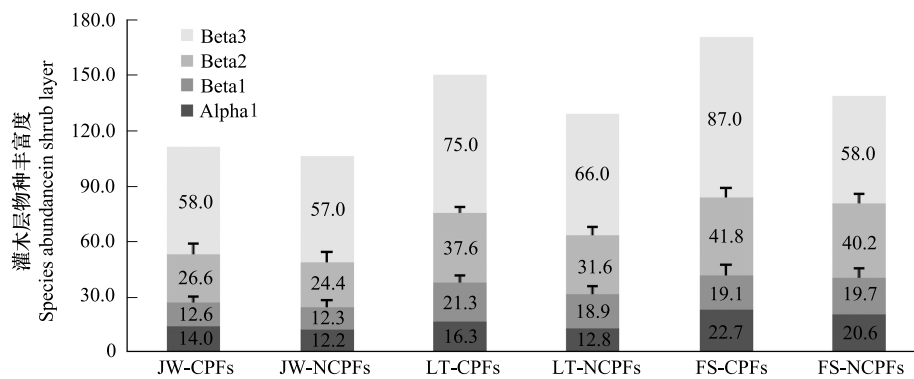


图3 村落文化林与非文化林灌木层物种丰富度的加性分配

Fig. 3 Additive partitioning of species abundance of shrub layer in community culturally protected forests and non-culturally protected forests

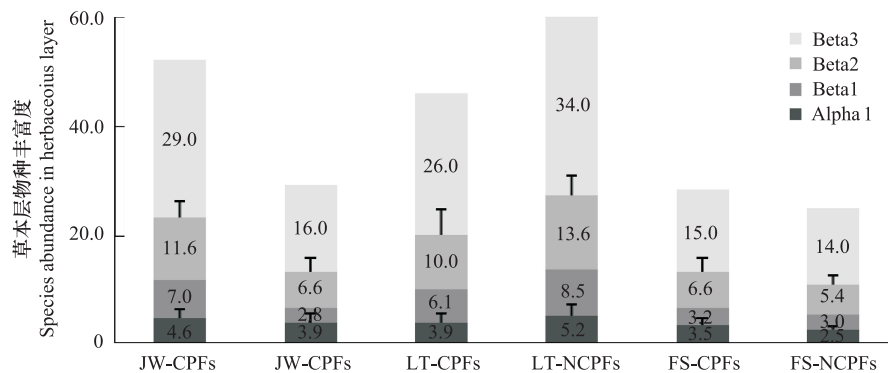


图4 村落文化林与非文化林草本层物种丰富度的加性分配

Fig. 4 Additive partitioning of species abundance of herbaceous layer in community culturally protected forests and non-culturally protected forests

化林乔木层保护的物种数。龙潭村物种累计曲线随面积增大逐渐平滑,汾水村物种累计曲线随面积增大已达到平滑,江湾村物种累积曲线随面积增加增长缓慢,可以用来估测文化林在区域尺度保护物种数目。相同面积下,文化林物种数随着面积的增加始终大于非文化林(图6),并且非文化林比文化林先达到了平滑,并增长

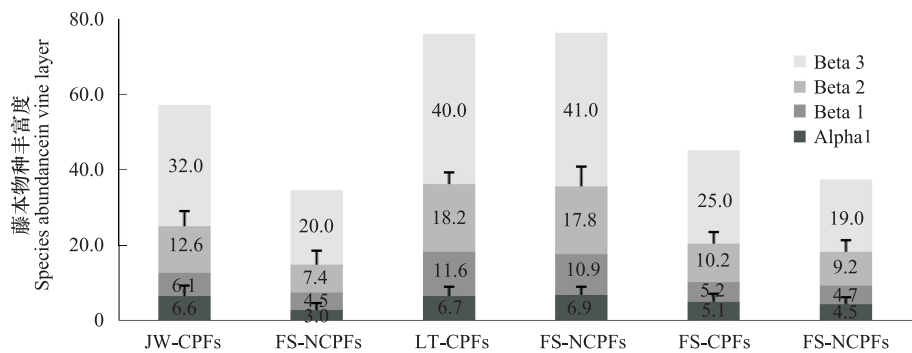


图5 村落文化林与非文化林藤本物种丰富度的加性分配

Fig. 5 Additive partitioning of species abundance of vine layer in community culturally protected forests and non-culturally protected forests

缓慢,说明相同面积下文化林中物种种类较多。

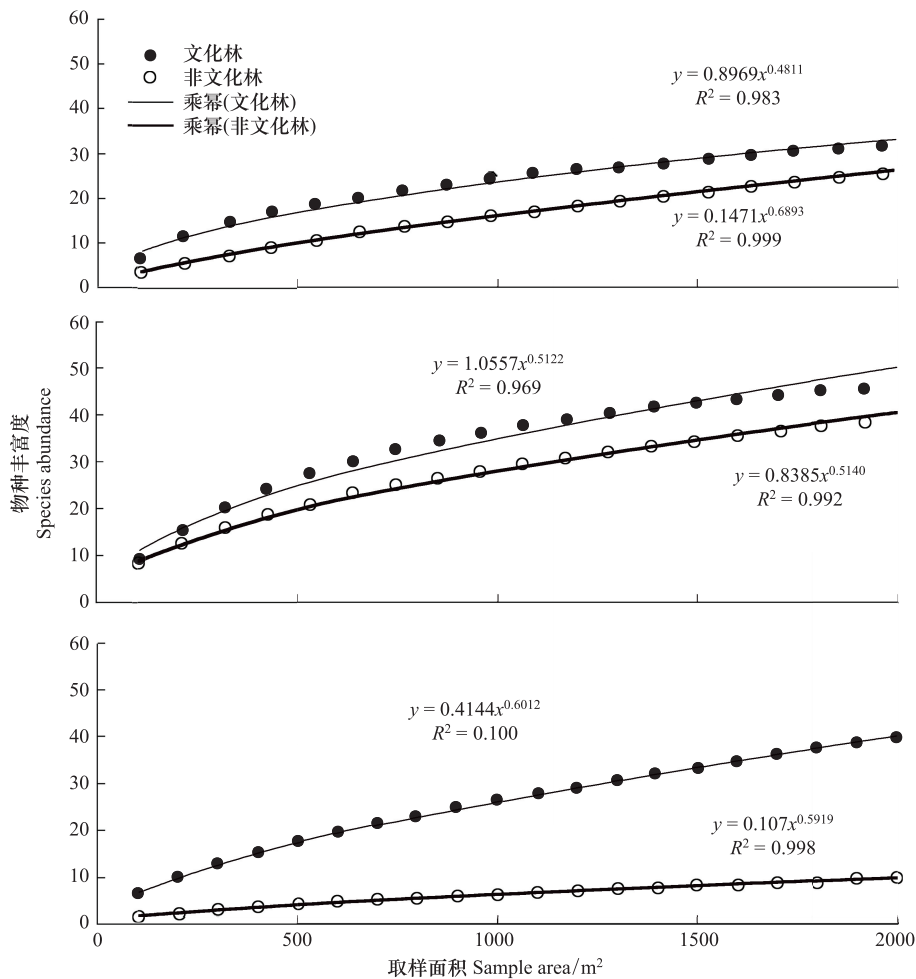


图6 龙潭村、汾水村、江湾村文化林与非文化林乔木物种累计曲线

Fig. 6 Species accumulation curve of tree layer in Longtan, Fenshui, Jiangwan culturally protected forests and non-culturally protected forests

3 讨论

文化林面积不大,但多样性较丰富,在保护区域物种多样性方面起到了重要的作用。文化林中的乔木层

以苦槠、樟、米槠为优势种,非文化林则以杉木、马尾松、毛竹等为主,说明文化林保存了多数的本土阔叶树种,而非文化林的乔木层逐渐被造林树种取代。灌木层多以油茶、木荷、紫金牛为优势种,而非文化林则以苦竹、茶、槲木为主。文化林与非文化林的草本层和藤本层的主要优势物种组成差异较小,部分文化林的物种较多,由于文化林群落位于村落周边,草本层受人畜干扰相对较严重。文化林的乔木层、灌木层、草本层和藤本层的物种多样性在区域尺度上,除龙潭村草本层、藤本层等之外,均高于非文化林,草本层和藤本层受干扰影响较大。总的来说,文化林维持了天然林的原始风貌,并且保护了一定本土物种,而非文化林乔灌木层受到干扰较大,优势物种由阔叶树种为主转成以针叶树种为主,并且物种数相对较少。

加性分配对区域物种多样性的贡献为文化林乔木层占 54.4%—81.0%,灌木层占 51.2%—55.2%,草本层占 42.9%—64.1%,藤本层占 49.9%—62.2%,文化林对区域总的物种多样性的贡献起到了主导作用,扮演着区域物种库的角色,尤其在保护乔木层物种方面。通过物种累积—面积曲线,对文化林与非文化林乔木层的物种数目进行评价,发现相同取样面积下文化林物种丰富度始终大于非文化林,文化林在相同面积下可以保护更多的物种。

从不同的尺度的分析文化林在区域物种多样性保护中的作用,为理解文化林的贡献和保护提供重要参考。通过对比不同尺度的物种丰富度,表明随着尺度的增大,Beta 多样性也增大,也反应了 Beta 多样性对每个尺度的环境异质性的响应,异质性越高,多样性越大^[35]。对区域物种多样性的贡献,最大来自林型间多样性(Beta3),其次是样方间多样性(Beta2)大于样格间多样性(Beta1)或者样格内多样性(Alpha1),林型间多样性对区域多样性的贡献为 41.9%—62.8%,说明林型间多样性是度量区域多样性的合适尺度^[22],并且具有较高的物种多样性和更替速率。相对非文化林来说,文化林的 Beta 多样性较高,因此在考虑保护或恢复生态系统的时候,主要应集中于保护文化林区域。由于文化林离村落很近,人为活动对多样性的影响有待进一步研究,另外,Kattan^[36]森林破碎化也可以增加 Beta 多样性。生物多样性的加性分配法则为生物多样性的多尺度研究不同组分关系的变化提供了有效地理论框架,可以广泛应用于空间尺度、时间尺度、组织尺度等^[37-39],有效地帮助进行保护决策。

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References:

- [1] Berkes F, Colding J, Folke C. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*, 2000, 10(5): 1251-1262.
- [2] Byers B, Cunliffe R, Hudak A. Linking the conservation of culture and nature: a case study of sacred forests in Zimbabwe. *Human Ecology*, 2001, 29(2): 187-218.
- [3] Fabricius C, Koch E, Turner S, Magome, Rights, resources and rural development: community-based natural resource management in Southern Africa. London: Cromwell Press Ltd, 2004.
- [4] Berkes F, Davidson-Hunt I. Biodiversity, traditional management systems, and cultural landscapes: examples from the boreal forest of Canada. *International Social Science Journal*, 2006, 58(187): 35.
- [5] Mgumia F, Oba G. Potential role of sacred groves in biodiversity conservation in Tanzania. *Environmental conservation*, 2003, 30(3): 259-265.
- [6] Bhagwat S A, Rutte C. Sacred groves: potential for biodiversity management. *Frontiers in Ecology and the Environment*, 2006, 4(10): 519-524.
- [7] Jamir S A, Pandey H. Vascular plant diversity in the sacred groves of Jaintia Hills in northeast India. *Biodiversity and conservation*, 2003, 12(7): 1497-1510.
- [8] Wassie A, Sterck F J, Bongers F. Species and structural diversity of church forests in a fragmented Ethiopian Highland landscape. *Journal of Vegetation Science*, 2010, 21(5): 938-948.
- [9] Ai H S. Deity mountain forest and its function in natural reservation in Gaoligong Mountain of Yunnan province. *Chinese Journal of Ecology*, 2003, 22(2): 92-96.

- [10] Zou L, Xie Z Q, Ou X K. Significance of Tibetan sacred hills in nature conservation of Shangri-La Gorge, Yunnan. *Biodiversity Science*, 2005, 13 (1).
- [11] Luo Y, Liu J, Zhang D. Role of traditional beliefs of Baima Tibetans in biodiversity conservation in China. *Forest Ecology and Management*, 2009, 257(10): 1995-2001.
- [12] Salick J, Amend A, Anderson D, Hoffmeister K, Gunn B, Zhendong F. Tibetan sacred sites conserve old growth trees and cover in the eastern Himalayas. *Biodiversity and conservation*, 2007, 16(3): 693-706.
- [13] Zou L L, Dao Z L, Long C L. Study on community forest resource management of the Zhuang nationality in Southeast Yunnan of China. *Journal of Plant Resources and Environment*, 2009, (01): 67-73.
- [14] Long C L, Zhang F Y, Pei S J, Chen S Y. Impacts of traditional culture of Yi nationality upon biodiversity in Zixishan Mountain area, Yunnan. *Chinese Biodiversity*, 1999, 7(003): 245-249.
- [15] Fang J M, Sun H, Zhang Y Z. The Significance of the Traditional Culture of Sichuan Tibetan Region to Biodiversity Protection. *World Sci-Tech R&D*, 2007, (04): 66-71.
- [16] Cui M K, Chen C. The Dai's traditional environmental knowledge and the forest management, in Xishuangbanna. *Journal of Yunnan Normal University(Social Science)*, 2002, 34(5).
- [17] Fen C Z, Wan Y T, You C L, A X X, Xu F R, Yu T Q, Tang C F, Dai L Y. Advances of using indigenous knowledge in biodiversity protection. *Journal of Plant Genetic Resources*, 2007, 8(3): 373-377.
- [18] Hu L, Li Z, Liao W, Fan Q. Values of village fengshui forest patches in biodiversity conservation in the Pearl River Delta, China. *Biological conservation*, 2011, 144: 1553-1559.
- [19] Mo X X, Zhu H, Zhang Y J, Slik J W F, Liu J X. Traditional forest management has limited impact on plant diversity and composition in a tropical seasonal rainforest in SW China. *Biological conservation*, 2011, 144(6): 1832-1840.
- [20] Lande R. Statistics and partitioning of species diversity, and similarity among multiple communities. *Oikos*, 1996, 76: 5-13.
- [21] Devries P J, Walla T R. Species diversity and community structure in neotropical fruit-feeding butterflies. *Biological Journal of the Linnean Society*, 2001, 74(1): 1-15.
- [22] Gering J C, Crist T O, Veech J A. Additive partitioning of species diversity across multiple spatial scales: implications for regional conservation of biodiversity. *Conservation Biology*, 2003, 17(2): 488-499.
- [23] Chen S B, Ou Yang Z Y, Xu W H, Xiao Y. A review of beta diversity studies. *Biodiversity Science*, 2010, 18(4): 323-335.
- [24] Chen S B, Ou Yang Z Y, Zheng H, Xiao Y, Xu W H. Latitudinal gradient in beta diversity of forest communities in America. *Acta Ecologica Sinica*. 2011, 31(5): 1334-1340.
- [25] Tylianakis J M, Klein A M, Lozada T, Tscharntke T. Spatial scale of observation affects α , β and γ diversity of cavity-nesting bees and wasps across a tropical land-use gradient. *Journal of Biogeography (J Biogeogr)*, 2006, 33: 1295-1304.
- [26] Ribeiro D B, Prado P I, Brown Jr K S, Freitas A V L. Additive partitioning of butterfly diversity in a fragmented landscape: importance of scale and implications for conservation. *Diversity and Distributions*, 2008, 14(6): 961-968.
- [27] Fahr J, Kalko E K V. Biome transitions as centres of diversity: habitat heterogeneity and diversity patterns of West African bat assemblages across spatial scales. *Ecography*, 2010, 34(2): 177-195.
- [28] Tang Z Y, Qiao X J, Fang J Y. Species-area relationship in biological communities. *Biodiversity Science*, 2009, 17 (6): 549-559.
- [29] Dengler J. Which function describes the species-area relationship best? A review and empirical evaluation. *Journal of Biogeography (J Biogeogr)*, 2009, 36: 728-744.
- [30] Flather C H. Fitting species-accumulation functions and assessing regional land use impacts on avian diversity. *Journal of Biogeography*, 1996, 23 (2): 155-168.
- [31] Colwell R K, Mao C X, Chang J. Interpolating, extrapolating, and comparing incidence-based species accumulation curves. *Ecology*, 2004, 85 (10): 2717-2727.
- [32] Ugland K I, Gray J S, Ellingsen K E. The species-accumulation curve and estimation of species richness. *Journal of Animal Ecology*, 2003, 72 (5): 888-897.
- [33] Zhang J T. *Quantitative Ecology*. Beijing: Science Press, 2004.
- [34] R. K. Colwell, <http://purl.oclc.org/estimates>.
- [35] Zhang Y X, Ma K M, Qi J, Feng Y, Zhang J Y. Multi-scale analysis of plant species diversity of Oak forest at Dongling Mountain, Beijing. *Acta Ecologica Sinica*, 29(5): 2179-2185.

- [36] Kattan G H, Franco P, Saavedra Rodríguez C A, Valderrama C, Rojas V, Osorio D, MartíNez J Ú S. Spatial components of bird diversity in the Andes of Colombia: implications for designing a regional reserve system. *Conservation Biology*, 2006, 20(4): 1203-1211.
- [37] Wagner H H, Wildi O, Ewald K C. Additive partitioning of plant species diversity in an agricultural mosaic landscape. *Landscape Ecology*, 2000, 15(3): 219-227.
- [38] Summerville K S, Boulware M J, Veech J A, Crist T O. Spatial variation in species diversity and composition of forest Lepidoptera in eastern deciduous forests of North America. *Conservation Biology*, 2003, 17(4): 1045-1057. Spatial variation in species diversity and composition of forest Lepidoptera: patterns and implications for conservation.
- [39] Crist T O, Veech J A. Additive partitioning of rarefaction curves and species-area relationships: unifying, and diversity with sample size and habitat area. *Ecology Letters*, 2006, 9(8): 923-932.

参考文献:

- [9] 艾怀森. 云南高黎贡山神山森林及其在自然保护中的作用. *生态学杂志*, 2003, 22(2).
- [10] 邹莉. 云南省香格里拉大峡谷藏族神山在自然保护中的意义. *生物多样性*, 2005, 13(1).
- [13] 邹绿柳, 刀志灵, 龙春林. 滇东南壮族社区森林资源管理分析. *植物资源与环境学报*, 2009, (01): 67-73.
- [14] 龙春林, 张方玉. 云南紫溪山彝族传统文化对生物多样性的影响. *生物多样性*, 1999, 7(003): 245-249.
- [15] 房俊民, 孙辉, 张炎周. 四川藏区传统藏文化对生物多样性保护的意义. *世界科技研究与发展*, 2007, (04): 66-71.
- [16] 崔明昆. 西双版纳傣族传统环境知识与森林生态系统管理. *云南师范大学学报(哲学社会科学版)*, 2002, 34(5).
- [17] 樊传章. 土著知识在生物多样性保护和利用中的研究进展. *植物遗传资源学报*, 2007, 8(3).
- [23] 陈圣宾, 欧阳志云, 徐卫华, 肖懿. Beta 多样性研究进展. *生物多样性*, 2010, 18(04): 323-335.
- [24] 陈圣宾, 欧阳志云, 郑华, 肖懿, 徐卫华. 美洲森林群落 beta 多样性的纬度梯度性. *生态学报*, 2011, 31(5): 1334-1340.
- [28] 唐志尧, 乔秀娟, 方精云. 生物群落的种-面积关系. *生物多样性*, 2009, 17(6): 549-559.
- [33] 张金屯. *数量生态学*, 北京: 科学出版社, 2004.
- [35] 张育新, 马克明, 祁建, 冯云. 北京东灵山辽东栎林植物物种多样性的多尺度分析. *生态学报*, 2009, 29(5): 2179-2185.

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