Response to classification numbers of vegetation types on correlative coefficients among landscape metrics

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Abstract It is important to analyze characteristics of landscape pattern indices for landscape ecological research but its development and application in the field has been limited because of complicated relationships among the indices. There are more than 100 indices used to describe characteristics of landscape system. In this research 28 indices were analyzed which were defined in three types of landscape indices [area/perimeter/density] shape and contagion. The basic characteristics of a regional landscape were based on maps of vegetation fraction grading which were translated from TM remote sensing images of Guangzhou on Oct. 22, 2005. This research was performed in the city center 8 districts of Guangzhou. All landscape indices were calculated with the software Fragstats 3. 3. At the level of class metrics correlative relationships among indices which were in the same type of classes were explored firstly. Then the response of the...
correlative relationships was studied under different classification systems of vegetation fraction for the same landscape[1] and seven kinds of classification systems of vegetation fraction were designed[1] namely 2[4] 3[5] 4[6] 5[7] 6[8] 9 and 17. The results of correlative relationships were as following[1] relationship between every index pair was obvious for almost all indices[1] but there were great difference among different index pairs. For the type of area/perimeter/density metrics the relationships were most significant[1] and for the type of shape metrics indices were strong independent from each other. Some indices[1] such as PD[9] have their different ecological meaning at the landscape level and at the class metrics level. This research got a conclusion[1] which was different from literatures[1] by calculating correlative relationship between PD and AREA_MN. It revealed that it should be important to choose suitable indices for the goal of research at the class level and the landscape level. The results on sensitivity of those indices to number of types were analyzed as following[1] most of indices were very sensitive to classification number of landscape types[1] and the response degree and tendency were different among different metrics. The response tendencies of 117 index pairs were divided into three groups according to their action under different numbers of landscape types[1] such as non-sensitiveness[1] monotonous increasing and complex[1] and the number of index pairs of each group was 12[1] 31[1] and 74[1] respectively. The response to the number of landscape types indicated that classification numbers 4 and 5 were most sensitive. Another result showed that response difference stood among different types of class metrics[1] and indices about Area/Perimeter/Density metrics was non-sensitive with changing of classification numbers of types. The metrics about shape of landscape was the most sensitive. Additionally[1] the results revealed that the correlative relationship of indices were related to spatial characteristics of position.

区域概况与研究方法

研究区概况

广州市位于珠江三角洲的中心腹地。研究区为广州市的中心城区，包括海珠、黄埔、荔湾、芳村区、越秀、天河、白云、东山区等，总面积488.22 km²。其中，面积最大的是白云区，面积最小的是越秀区。研究区地势东北高，西南低，北部和东北部是山区，中部是丘陵、盆地，南部是珠江三角洲沿海冲积平原。气候类型为南亚热带典型的季风海洋性气候。

研究方法

以AB遥感影像为本研究的数据源，数据接收时间为2005年1月22日，轨道号为1223894（122上移）。辅助图件主要为广州市行政区划图（2001年区划图）、地形图（1:25万）。主要软件有ERDAS Imagine、Arcinfo9.3、Fragstats3.3、SPSS12.0等图像处理软件和景观格局分析软件。统计分析采用LMLL12N等。

遥感图像经过预处理和大气辐射校正，剔除大气辐射“噪声”的影响，计算校正后的归一化植被指数，建立植被指数与植被覆盖度的关系模型，再进行遥感图像的空间模型运算，形成研究区的植被覆盖度分布图。按照研究所确定的植被覆盖度等级体系，分割植被覆盖图生成一系列不同分类数的植被覆盖度等级图；然后用广州市老八区行政边界裁剪植被覆盖度等级图，形成各行政区域范围内的一系列不同分类数的植被覆盖度等级图。在类型水平上，利用Landscape计算各行政区域不同植被覆盖度等级的景观格局指数，按Landscape对景观格局指数的分类，选取19个面积、周长和密度指数，4个形状指数、5个蔓延度指数、1个连接度指数和2个分离度指数等4类共22个指数，按照指数的生态学意义归并成本研究的面积、周长、密度类指数（9个）、形状类指数（9个）、蔓延度类指数（16个）等9个类型。计算各指数值的自然对数，用LMLL12N计算各类型内部的各指数间、指数与其自然对数间和自然对数与自然对数间的相关系数。选取绝对值最大的值作为两个指数间的相关系数（r）。规定T < 0.05为极显著相关；T < 0.01<T U < 0.05为显著相关；T < 0.05为弱相关；r的正负号表示相关的方向。

参考有关文献[29,7,25,1],结合研究区大于24C的植被覆盖度所占比例极少的实际，采用以下几种方案定义植被覆盖度分级体系：2级表示法（74=C、4=C 12=C）。

1.2

TM

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些指数表征景观格局特征时则存在着大量的信息冗余和生态学意义的重叠。本研究类型水平上，相关系数为负值，且相关性低于弱相关。但是布仁仓等研究：个指数在景观水平时呈完全正相关关系。表明该指数对在表征景观斑块时其响应完全同质，但在表征类型斑块时则相互独立。因为类型水平下，是某类型景观的斑块数与景观总面积的比值，而景观水平下是景观中总斑块数与景观总面积的比值。显然不同研究水平上具有不同的生态学意义和空间意义。

### 表1 比较面积周长密度指数间的相关系数

<table>
<thead>
<tr>
<th></th>
<th>PLAND</th>
<th>NP</th>
<th>PLD</th>
<th>LPI</th>
<th>TE</th>
<th>ED</th>
<th>AREA_MN</th>
<th>AREA.CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>0.8968</td>
<td>0.8652</td>
<td>0.6612</td>
<td>0.7990</td>
<td>0.9746</td>
<td>0.8988</td>
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<td>PLAND</td>
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<td>0.6202</td>
<td>0.9814</td>
<td>0.7921</td>
<td>0.9667</td>
<td>0.9600</td>
<td>0.7406</td>
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</tr>
<tr>
<td>NP</td>
<td>0.8280</td>
<td>0.3089</td>
<td>0.9471</td>
<td>0.6507</td>
<td>0.3471</td>
<td>0.8021</td>
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<tr>
<td>PLD</td>
<td>0.4327</td>
<td>0.7560</td>
<td>0.7964</td>
<td>−0.2982</td>
<td></td>
<td>0.6383</td>
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<td>LPI</td>
<td>0.6494</td>
<td>0.8695</td>
<td>0.9402</td>
<td>0.6827</td>
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<td>TE</td>
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<td>0.4572</td>
<td>0.9272</td>
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<td>ED</td>
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<td>0.8105</td>
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<td></td>
</tr>
<tr>
<td>AREA_MN</td>
<td></td>
<td>0.4402</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level [2-tailed]*

### 表2 比较形状指数间的相关系数

<table>
<thead>
<tr>
<th></th>
<th>SHAPE_MN</th>
<th>FRAC_MN</th>
<th>PARA_MN</th>
<th>CIRCLE_MN</th>
<th>CONTIG_MN</th>
<th>NLSI</th>
<th>GYRATE_MN</th>
<th>GYRATE.CV</th>
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</thead>
<tbody>
<tr>
<td>LSI</td>
<td>0.0599</td>
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<td>SHAPE_MN</td>
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<td>−0.385</td>
<td>0.4842</td>
<td>0.2982</td>
<td>−0.6925</td>
<td>−0.2086</td>
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<tr>
<td>FRAC_MN</td>
<td>0.7083</td>
<td>−0.4100</td>
<td>0.0841</td>
<td>0.6922</td>
<td>−0.3424</td>
<td>0.9415</td>
<td>0.4496</td>
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<tr>
<td>PARA_MN</td>
<td>−0.8321</td>
<td>0.7345</td>
<td>0.8194</td>
<td>−0.6192</td>
<td>0.4496</td>
<td>0.1995</td>
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<tr>
<td>CIRCLE_MN</td>
<td>−0.8363</td>
<td>−0.8976</td>
<td>0.7016</td>
<td>−0.3177</td>
<td>−0.0931</td>
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<tr>
<td>CONTIG_MN</td>
<td>0.5514</td>
<td>−0.6764</td>
<td>−0.2735</td>
<td>−0.1754</td>
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<tr>
<td>NLSI</td>
<td>−0.632</td>
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<td>0.2807</td>
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<td>GYRATE_MN</td>
<td>−0.2997</td>
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</tbody>
</table>

*Correlation is significant at the 0.05 level [2-tailed]*
表3 蔓延度指数间的相关系数

<table>
<thead>
<tr>
<th></th>
<th>ENN_MN</th>
<th>CLUMPY</th>
<th>PLADJ</th>
<th>IJI</th>
<th>COHESION</th>
<th>DIVISION</th>
<th>MESH</th>
<th>SPLIT</th>
<th>AI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENN_CV</td>
<td>-0.6656</td>
<td>-0.8700*</td>
<td>-0.7429*</td>
<td>0.5087*</td>
<td>-0.6680*</td>
<td>0.5069*</td>
<td>-0.7907*</td>
<td>0.9369*</td>
<td>-0.7175*</td>
</tr>
<tr>
<td>CLUMPY</td>
<td>0.7030*</td>
<td>-0.268</td>
<td>0.2506</td>
<td>0.2868</td>
<td>0.5569*</td>
<td>-0.5676*</td>
<td>-0.7987*</td>
<td>-0.3073</td>
<td></td>
</tr>
<tr>
<td>PLADJ</td>
<td>0.8963*</td>
<td>-0.1151</td>
<td>0.9318*</td>
<td>-0.086</td>
<td>0.6365*</td>
<td>-0.8949*</td>
<td>0.8888*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IJI</td>
<td>-0.3872</td>
<td>0.9745*</td>
<td>-0.6263*</td>
<td>0.945*</td>
<td>-0.942*</td>
<td>0.9941*</td>
<td></td>
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</tr>
<tr>
<td>COHESION</td>
<td>-0.245</td>
<td>0.4961*</td>
<td>-0.3494</td>
<td>0.4996*</td>
<td>-0.3729</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>DIVISION</td>
<td>-0.4098</td>
<td>0.8686*</td>
<td>-0.8342*</td>
<td>0.9607*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MESH</td>
<td>-0.6316*</td>
<td>0.7126*</td>
<td>-0.6316*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SPLIT</td>
<td>-0.9650*</td>
<td>0.9223*</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

该类指数中,分离度(\(I_{\text{Hi}}\))与所有其它指数都呈相关,除\(|r| \leq 0.55\)外,其余全部呈极显著相关,且负极显著相关个数达2个。显然,\(I_{\text{Hi}}\)是该类指数中最具代表性的指数。而\(|r| \leq 0.55\)是最具独立性的指数,\(|r| \leq 0.55\)与其余11个指数中的相关系数全部未达显著相关水平,其余4个指数对相关系数仅2个达极显著相关。

2.2 景观指数间的相关关系对景观分类的敏感性

基于不同的植被覆盖度等级划分方案,计算不同分类数下各类型指数内景观格局指数两两之间的相关系数,研究相关关系对分类数变化的响应。大类共28个指数形成66个指数对,根据曲线变化将指数对之间相关关系对分类数的响应分成4类,如图K。

2.2.1 简单型

图K所示的\(K_{\text{H}}\)个指数对之间的相关性对景观分类数的响应不敏感,即随着分类数增加,相关系数的值变化较小,响应曲线微小波动。

2.2.2 分段变化型

共\(J_{\text{K}}\)个指数对的相关系数呈现分段变化的趋势(如图H)。其中,图H-的\(G_{\text{K}}\)个指数对的相关性从负相关到正相关变化,指数对在小的分类数时显著负相关,随着分类数增加,相关性减弱,至分类数\(D_{\text{K}}\)时呈正相关,以后相关性逐渐增强。图H的\(D_{\text{K}}\)个指数对的相关性随着分类数增加均由正相关向负相关过渡,变幅较

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2.2.3  

Fig. 2. Correlation coefficients of indexes plotted against the number of landscape types.
图3 景观格局指数间相关系数对景观分类数变化的响应曲线
Fig.3 Correlation coefficients of indexes plotted against the number of landscape types
在分类数较小时从显著正相关跳跃式变为显著负相关，而变化杂乱，都在正负相关之间变化着，表现出对分类数响应极为敏感。

综上所述，面积、周长密度类指数间的相关性对分类数依赖性较差，图中不敏感的指数对就有属该类型，图中变化较规则的指数属于该类型。按面积周长密度类、形状类和蔓延度类分类，分别计算各类型中指数对的相关系数随分类数变化的变异系数，取其绝对值求平均值，分别为\( \frac{1}{2} \frac{1}{4} \frac{1}{17} \)、\( \frac{1}{2} \frac{1}{4} \frac{1}{17} \)、\( \frac{1}{2} \frac{1}{4} \frac{1}{17} \)，进一步证实形状类指数间的相关关系对分类数变化的响应最强，其次是蔓延度指数类，面积周长密度类指数的响应最弱。

以常用的对分类数不敏感的和敏感性强的指数对为例，研究相对丁分类数时相关系数的空间分异。如表1、图1所示，除白云区外，其余各行政区域范围内的相关系数随分类数变化有较小的变化，其中，越秀区和荔湾区内无变化。变化最大的白云区主要表现在高分类数时，呈下降趋势，降幅为\( \frac{1}{2} \frac{1}{4} \)。越秀区和荔湾区是广州市面积最小（分别为\( \frac{1}{2} \frac{1}{4} \frac{1}{17} \)）的两个中心城区，区域内植被主要以城市绿地为主，覆盖度的城市绿地占绝对优势，等级单一，在不同分类数下两指数之间的相关关系都相当于单一的一个等级的平均斑块面积及该等级斑块面积占总景观面积的百分比之间的关系，其相关系数为\( \frac{1}{2} \frac{1}{4} \)。白云区是研究区内面积最大的行政区（\( \frac{1}{2} \frac{1}{4} \frac{1}{17} \)），植被覆盖度等级的结构变复杂，随分类数增大，指数间的相关关系的波动出现分异。指数对的相关性在分类数时转化为弱相关，是较大分类数时各等级植被覆盖度斑块间的平均面积差异较大所致。表明细致的分类更能体现出景观结构的差异性。
图 4 空间格局指数间相关关系对景观形状指数的影响

a 分类数 3 Number 3 of types  b 分类数 4 Number 4 of types  c 分类数 5 Number 5 of types  d 分类数 17 Number 17 of types

图例 Legend

0.55(0) 0.55,0.75 0.75,1.00

图 4 Spatial pattern of sensitivity to numbers of classes for the correlation coefficient between contiguity index and landscape shape index

a 分类数 3 Number 3 of types  b 分类数 4 Number 4 of types  c 分类数 5 Number 5 of types  d 分类数 17 Number 17 of types

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被变化的一二级分类系统,然后分别研究
局研究中必须十分注意的问题。
系受到分类数的影响,那么,一级研究水平下选定的有代表性的景观特征指数是否在二级水平下仍然具有代
著相关,而在分类数
景观格局特征。另外,精细的景观分类能更好地反映景观格局的细节特征。
是对于形状和景观斑块分布状态类的景观格局指数的选取与应用。长期以来,由于客观景观的复杂性以及人
们认知与研究手段的局限性,这个问题一直受到忽略。对此,本文进行了探索性的研究,如果能够进行分类数
对景观格局指数之间相关关系的影响及定量关系的进一步研究,将有益于选取景观格局指数得出更为符合实
际的研究结果,并推动景观生态学的发展。

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