Effects of Changing Spatial Scale on the Results of Statistical Analysis with Landscape Data: A Case Study

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Abstract

The effect of scale on spatial analysis has long, but sporadically, been recognized in human geography and more recently and acutely in landscape ecology. As the number of studies directly and systematically addressing scale effects is still limited, it remains unclear how results of different statistical analyses are affected by changing scale for different landscapes, or whether or not such effects can be predicted and, if so, in what situations. However, it is certain that erroneous conclusions may result if scale effects are not considered explicitly in spatial analysis with area-based data. With widespread use of remote sensing data and GIS, a better understanding of the issue of scale effects is much needed. The main purpose of this study, therefore, was to examine how results of statistical analysis respond to a systematic change in the scale of analysis. Specifically, we investigated how the relationship between landscape metrics (local landcover diversity and richness indices) and independent variables (TM bands and vegetation indices) would change with different sample sizes and mathematical representations of variables. The landscape under study is the Minden area of Nevada in the western Great Basin. Four different sample sizes (19x19, 15x15, 11x11, and 5x5 pixels) and four different representation forms (variance, mean, variance-mean ratio, and coefficient of variation) of the variables were used in all statistical analyses. We systematically examined the effects of changing sample size and representations of variables on the results of regression, analysis of variance, and correlation analysis. The results indicated that the relationship between landscape metrics and TM bands and vegetation indices was affected considerably by the change of sample size. Both the R^2 value and the level of statistical significance of the relationship tended to increase as sample size increased. In addition, the results of ANOVA showed that the relative importance of the TM bands and vegetation indices in the relationship varied with sample size as well. Although the spatial pattern of local-scale (or "neighborhood") diversity and richness of land-cover types in this Great Basin landscape could be adequately quantified using spectral information-based variables, the results and accuracy of such a analysis depended on both landscape composition and sample size. The linear response of the statistical relationship to the change in sample size over some range of scales indicated that scale effects could be readily predicted in certain cases. However, in general, because scale effects can further be complicated by the choice of variables and the idiosyncrasy of particular landscapes, the predictability of scale effects seems to be confined only to certain domains of scale. To find these domains multiple-scale or hierarchical analysis must be performed. This study further supports that the modifiable areal unit problem is a common one across the disciplinary boundaries of geography, ecology and other earth sciences. Unraveling the problem not only will improve our understanding of pattern and process in nature, but also will have important implications for appropriate use of remote sensing data and GIS.