

# **Spatial dependence of predictions from image segmentation: a variogram-based method to determine appropriate scales for producing land-management information**

Jason W. Karl<sup>1,2</sup>, Brian A. Maurer<sup>2</sup>

<sup>1</sup> *Idaho Chapter of The Nature Conservancy, Boise, Idaho, USA*

<sup>2</sup> *Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI, USA*

A significant challenge in ecological studies has been defining scales of observation that correspond to the relevant ecological scales for organisms or processes of interest. Remote sensing has become commonplace in ecological studies and management, but the default resolution of imagery often used in studies is an arbitrary scale of observation. Segmentation of images into objects has been proposed as an alternative method for scaling remotely-sensed data into units having ecological meaning. However, to date, the selection of image object sets to represent landscape patterns has been largely subjective. Changes in observation scale affect the variance and spatial dependence of measured variables, and may be useful in determining which levels of image segmentation are most appropriate for a given purpose. We used observations of percent bare ground cover from 346 field sites in a semi-arid shrub-steppe ecosystem of southern Idaho to look at the changes in spatial dependence of regression predictions and residuals for 10 different levels of image segmentation. We found that the segmentation level whose regression predictions had spatial dependence that most closely matched the spatial dependence of the field samples also had the highest predicted-to-observed correlations. This suggested that for percent bare ground cover in our study area an appropriate scale could be defined. With the incorporation of a geostatistical interpolator to predict the value of regression residuals at unsampled locations, however, we achieved consistently high correlations across many segmentation levels. This suggests that if spatial dependence in percent bare ground is accounted for, a range of appropriate scales could be defined. Because the best analysis scale may vary for different ecosystem attributes and many inquiries consider more than one attribute, methods that can perform well across a range of scales and perhaps not at a single, ideal scale are important. More work is needed to develop methods that consider a wider range of ways to segment images into different scales and select sets of scales that perform best for answering specific management questions. The robustness of ecological landscape analyses will increase as methods are devised that remove the subjectivity with which observational scales are defined and selected.

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