A Decision Framework for Local Indicators for Categorical Data (LICD)

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Abstract

Local indicators for categorical data (LICD) are a spatially local method for quantifying spatial pattern in binary spatial data. In this paper we demonstrate how to apply LICD by developing a framework for their use and providing an example of their application in a study of forest pattern in a landscape heavily impacted by the mountain pine beetle. A dataset representing 2006 forest conditions is employed for evaluating spatial pattern of 'forest' and 'non-forest' components. Our framework outlines research decisions that must be made when implementing LICD. We provide a synthesis of options and implications for each stage. In a forested region LICD are demonstrated to be useful in detecting regions of heavily fragmented forest and deviations from an expected spatial pattern. This research is intended to provide guidance on the use of LICD and introduces a suite of computational tools which aid in their use in a GIS environment.

Background and Relevance

Landscape pattern indices (LPIs) have become the method of choice for quantifying the spatial pattern of landcover features. LPIs are a spatially global method for quantifying spatial pattern, and attempts at 'localizing' LPI measurements have generally employed a fishnet (Riitters et al. 2002) or random window approach (Potvin et al. 2001) with numerous smaller extents. There may however, be a minimum spatial extent when utilizing LPIs due to the formulation of many of these indices (Hargis et al. 1997). Furthermore, there are a number of issues associated with the use of LPIs including; correlation among metrics (Riitters et al. 1995), lack of statistical testing (Remmel & Csillag 2003) and a number of scaling relations (Wu 2004). Local indicators for categorical data (LICD) have been developed as a spatially local method for performing landscape pattern analysis on categorical spatial data which address some of the issues associated with LPIs (Boots 2003, 2006).

We refer to spatial pattern in categorical landcover data as having two primary components: *composition* and *configuration* (Gustafson 1998). Composition is a relatively easily quantifiable entity. Configuration however, is more complex and has been demonstrated to have a known, systematic and often non-linear relationship with composition (Remmel et al. 2002). LICD address the issues of correlation among metrics by incorporating what are believed to be the 5 major components of configuration (Boots 2006). LICD also enable exploratory statistical testing, by testing for significant deviation in local patterns against what would be expected by chance (Boots 2006). LICD address the issue of configurational dependence on composition through direct comparison of only those local windows with the same composition. Scaling issues need to be considered when implementing LICD and we propose a multi-scale approach with clear justifications of scale choices as has been advised for use with LPIs (Wu 2004).

Data and Methods

Landcover information (circa year 2000) has been developed for the entirety of Canada's forested landscapes as part of the earth observation for sustainable development of forests (EOSD) program (see Wulder et al. 2003). Using a change detection algorithm (Han et al. 2007) with Landsat imagery, we update the 2000 data to 2006 conditions. A binary representation of landcover is facilitated with the EOSD data through a nested class hierarchy which can easily be aggregated to two classes: forest and non-forest (Wulder & Nelson 2003).

As part of this research we have developed a decision framework for implementing LICD. This framework identifies the decisions that an analyst encounters when utilizing LICD. We conduct a synthesis of the analysis options available and provide a set of implementation guidelines. We implement LICD in a forested region that has been heavily impacted by the mountain pine beetle and subsequent large-salvage harvest operations. These disturbances have substantially altered the landscape in this region. It is important to quantify the changes in spatial pattern as it is known to impact ecological function (e.g., hydrology (Helie et al. 2005), carbon budget (Kurz et al. 2008) and wildlife habitat (Bunnell et al. 2004)). We focus on quantifying patch scale patterns using LICD. Based on Boots (2006) we implement five configurational LICD and the lone compositional LICD to characterize local spatial pattern in a forest environment following large-scale forest disturbance.

Results and Conclusions

We found LICD to be useful in characterizing regions as fragmented or patchy relative to randomness. An applicable scale for implementing LICD in a forested environment was also determined. Output of this research consists of maps portraying local spatial characteristics for our study area. Inference based on these maps provides insight into the spatial processes occurring across our study area.

We feel that LICD are a readily applicable method for spatially local landscape pattern analysis that has yet to reach its full potential in the peer-reviewed research community. We provide an application of LICD in a forested region that can be used as a reference for future research. We also provide a framework that includes guidelines for implementing LICD. Currently, userfriendly GIS-based software for LICD analysis is lacking. We intend to provide computational tools that will increase the ease of use of these methods.

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