Applied Geography 52 (2014) 204–211

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

Fractally deforested landscape: Pattern and process in a tri-national Amazon frontier

Jing Sun [a,*], Zhuojie Huang [b], Qiang Zhen [c], Jane Southworth [d], Stephen Perz [e]

[a] Center for Systems Integration and Sustainability, Michigan State University, East Lansing, MI 48823, USA
[b] GeoVISTA Center, Penn State University, 302 Walker, University Park, PA 16802, USA
[c] Department of Mathematics & Statistics, University of North Florida, Jacksonville, FL 32224, USA
[d] Department of Geography, University of Florida, Gainesville, FL 32611, USA
[e] Department of Sociology and Criminology & Law, University of Florida, Gainesville, FL 32611, USA

Keywords:
Amazon
Deforestation
Fractal analysis
Fixed-grid scans
Bottom-up plan
Configuration scheme

A B S T R A C T

Forest clearings in the Amazon are expanding along roads and are enhanced by the associated expansion of human settlements. The purpose of this research is to analyze the spatial patterns associated with this development process using fractal geometry and to partition this development process into different levels by a model-based classification scheme that can be applied to regions globally. A critical region of tropical forest cover in the tri-national frontier in the center of the southwestern Amazon was used as the study area. We utilized box-counting fractal dimensions to describe the spatial patterns of deforestation at a pixel level from 1986 to 2010 in the study region. The evolving pattern of development, as indicated by density-sliced fractal dimension, provides a unique and informative view of a deforesting landscape. The cleared areas have become increasingly compact from 1986 to 2010, where the low fractal dimensions typically represent little to no forest clearings and higher fractal dimensions are associated with more highly developed areas. Such differences are summarized by a classification scheme derived from a mathematical model that partitions the continuous range of fractal dimensions into five possible classes ranging from no or minimal development to highly developed. Such graphical representations of these stages of deforestation in the study region with such spatially explicit pixel-level information enables us to provide multi-level, local, adaptive, and flexible information to forest conservation groups, land managers and related programs.

© 2014 Elsevier Ltd. All rights reserved.

Introduction

Human society is undergoing a rapid transformation associated with development that will eventually produce a post-industrial era and associated landscapes. Such drastic transitions have already produced potentially threatening changes in almost every aspect of our social-ecological systems (Gunderson & Holling, 2002), and abrupt global environmental changes can no longer be excluded (Scheffer et al., 2009; Scheffer, Carpenter, Foley, Folke, & Walker, 2001). Among them, land use and land cover changes are occurring globally and at increasingly unprecedented rates, impacting almost all major biomes worldwide (Gutman et al., 2004; Lambin & Geist, 2006). This is especially true of the process of large-scale deforestation occurring throughout the Amazon, which has received considerable attention over the past several decades (Laurance et al., 2002; Lima et al., 2012; Messina, Walsh, Mena, & Delamater, 2006; Nepstad et al., 2001).

Deforestation has a strong influence on regional and global climates (Malhi et al., 2008). For example, the consumption of the cleared forests (e.g., fuel wood) produces greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, which play an important role in exacerbating global warming (Fearnside, 2004). Deforestation may also signal an impending biodiversity loss or even a biotic collapse (Nobre, Malagutti, Urbano, de Almeida, & Giarolla, 2009) caused by the loss of landscape connectivity, both structural and functional because the persistence of spatially structured species populations, or meta-populations, is strongly related to landscape connectivity (Hanski & Ovaskainen, 2003). However, the process of deforestation serves to increase forest fragmentation, breaking continuous forests into discrete patches

* Corresponding author.
E-mail addresses: jingsun@msu.edu, sunjingchanges@gmail.com (J. Sun), zxh6@psu.edu (Z. Huang), q.zhen@unf.edu (Q. Zhen), jsouthwo@ufl.edu (J. Southworth), sperz@ufl.edu (S. Perz).

http://dx.doi.org/10.1016/j.apgeog.2014.05.011
0143-6228/© 2014 Elsevier Ltd. All rights reserved.