ASSESSING AND EVALUATING RECREATION RESOURCE IMPACTS: SPATIAL ANALYTICAL APPROACHES

by

Yu-Fai Leung

Dissertation submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Forestry

Jeffrey L. Marion, Chair
W. Michael Aust
James B. Campbell
Laurence W. Carstensen
R. Bruce Hull, IV

April, 1998
Blacksburg, Virginia

Key words: recreation ecology, impact assessment, trails, campsites, spatial analysis, spatial indices, multivariate methods, Great Smoky Mountains National Park

ASSESSING AND EVALUATING RECREATION RESOURCE IMPACTS: SPATIAL ANALYTICAL APPROACHES

by

Yu-Fai Leung

Committee chairman: Dr. Jeffrey L. Marion

Department of Forestry

(ABSTRACT)

It is generally recognized that the magnitude of recreation resource impacts should be judged by their severity and spatial qualities, including extent, distribution, and association. Previous investigations, however, have primarily focused on assessing the severity of impacts, with limited examination of spatial qualities. The goal of this dissertation was to expand our understanding of the spatial dimension of recreation resource impacts and their assessment and evaluation. Two empirical data sets collected from a comprehensive recreation impact assessment and monitoring project in Great Smoky Mountains National Park provided the basis for the analyses. Three spatial issues were examined and presented as three papers, designed for journal submission.

The purpose of the *first* paper was to improve our understanding of the dimensional structure and spatial patterns of camping impacts by means of multivariate analyses and mapping. Factor analysis of 195 established campsites on eight impact indicator variables revealed three dimensions of campsite impact: land disturbance, soil and groundcover damage, and tree-related damage. Cluster analysis yielded three distinctive campsite types that characterize both the intensity and areal extent of camping impacts. Spatial patterns and site attributes of these three campsite types and an additional group of primitive campsites were

illustrated and discussed.

The purpose of the *second* paper was to examine the influence of sampling interval on the accuracy of selected trail impact indicator estimates for the widely applied systematic point sampling method. A resampling-simulation method was developed and applied. Simulation results indicated that using systematic point sampling for estimating lineal extent of trail impact problems can achieve an excellent level of accuracy at sampling intervals of less than 100 m, and a reasonably good level of accuracy at intervals between 100 and 500 m. The magnitude of accuracy loss could be higher when the directions of loss are not considered. The responses of accuracy loss on frequency of occurrence estimates to increasing sampling intervals were consistent across impact types, approximating an inverse asymptotic curve. These findings suggest that systematic point sampling using an interval of less than 500 m can be an appropriate method for estimating the lineal extent, but not for estimating occurrence of trail impacts. Further investigations are called for to examine the generalizability of these results to other areas.

The purpose of the *third* paper was to expand the scope of indices used for evaluating recreation resource impacts. Two specific objectives were to synthesize the recreation ecology and recreation resource management literature on the use of spatial indicators and indices, and to propose and apply selected spatial indices that are mostly lacking in the literature. Three spatial indices primarily adapted from the geography and ecology literature were proposed for application in recreation impact evaluation. Application results demonstrated that the Lorenz curve and associated Gini coefficient, and the linear nearest-neighbor analysis and associated LR ratio were effective in quantifying the spatial distribution

patterns of trail impacts at landscape and trail scales, respectively. Application results of the third index, the impact association index, were less promising and require further refinements.

Management implications and future directions of research were discussed in light of the findings of this dissertation. As the field of recreation ecology is emerging, this dissertation has demonstrated: (1) the value of recreation impact assessment and monitoring programs in providing data for examining the spatial dimension of impacts, and (2) the utility of spatial analytical approaches in understanding recreation impact assessment and evaluation.

ACKNOWLEDGMENTS

First and foremost, I would like to extend my sincere appreciation to my advisor and committee chair, Dr. Jeffrey L. Marion, for his constant support, guidance and encouragement throughout my doctoral program. I am honored to work under his supervision and experience his wisdom, knowledge and dedication to the field of recreation ecology. I am also indebted to other members of my committee: Dr. R. Bruce Hull for challenging me with methodological and ethical questions and for providing advice in multivariate statistics; Dr. W. Michael Aust for providing advice in research methodologies and forest management issues; Dr. James B. Campbell for offering advice in spatial analysis and for encouraging me to explore multivariate methods in his class; and Dr. Laurence W. Carstensen for introducing me to the world of geographic information science.

I am grateful to Sue Snow and Carole Salmon in the Forestry Department, for their dedicated administrative support. Encouragement from Dr. Gregory N. Brown, Dr. Harold E. Burkhart, and Dr. Timothy G. Gregoire have motivated me to move things forwards. I would also like to thank past and current graduate students for their warm encouragement throughout these years.

Janet Ferguson, a graduate student in the Geography Department, provided invaluable help in field work. Chris Lichty, Kurt Stromberg, Sam Doan, and several assistants assisted in campsite and trail surveys in the Great Smokies. Peter Williams provided invaluable input in campsite and trail survey design. I thank them all for their dedication and professionalism that contribute to the high-quality data sets on which this dissertation is based.

I am grateful for the generous funding support provided by the USDI National Park Service (Great Smoky Mountains National Park), the USDA Forest Service (Jefferson National Forest), and the West Virginia State Department of Natural Resources. Their funding support made this dissertation possible. I would particularly like to thank the park staff in the Great Smokies, including Carroll Schell and Kenny Slay, for their logistical support.

Last but not least, my family and friends back in Hong Kong and in Blacksburg have been the greatest source of motivation. The patience, understanding and care of my wife, Laura, are so comforting that this dissertation would not have been completed without her.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONT'D)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (CONT'D)