Analysis of Cumulative Impacts on Biotic and Abiotic Responses

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Introduction

The effects of contemporary intensive forest management activities on stream ecosystems are being studied at the Hinkle Creek Paired Watershed Study. As a part of this study, the cumulative effects of contemporary forest management activities on the physical, biological, chemical characteristics of the terrestrial, riparian and aquatic ecosystems are being studied at the scale of a complete 5,000-acre watershed.

A study plan authored by the principal investigators of the Hinkle Creek Paired Watershed Study identified the complex interactions among these systems and the need to integrate multiple response variables over multiple spatial and temporal scales. The analysis of the interactions is further complicated by their association along a stream network. The data obtained from a stream network include characteristics that increase the complexity of any resultant analysis.

1. Spatial autocorrelation in a stream network is a concern when data are collected in close physical proximity. Spatial analysis methods for stream networks need to account for distance between points along the network, not as-the-crow-flies distance. But such analysis methods for networks are not used routinely or available in existing software.

2. Connectivity or neighbor relationships (in spatial analysis) between points must account for flow patterns through the network. In some cases the connectivity relationships are clear (e.g. sediment flows downstream) and other cases may be more difficult to elucidate (e.g. how far up and down stream do amphibians move?).

An important objective in the Hinkle Creek Study is the integration of responses from multiple spatial and temporal scales to examine the downstream cumulative impacts of management on the subject area responses. Comments by reviewers of the original study plan pointed out the need for a better description of the data analysis that would consider cumulative impacts and better describe the integration that would occur between the original disciplinary projects. Such an analysis and integration must appropriately account for flow through the system and for spatial autocorrelation at the relevant scale. This project would develop the appropriate analysis methods for data from stream networks and describe how data from the individual disciplinary research projects would be integrated. These methods would be applicable to any ecological network and specifically apply to the multiple response variables in paired-watershed studies designed to address cumulative impacts of forest management on biotic and abiotic components of stream systems.

Objectives

1. Summarize existing statistical models used in natural resources and quantitative ecology to account for flow and autocorrelation for data from stream networks.
2. Evaluate the adequacy of these methods for the analysis of cumulative effects in paired-watershed studies.

3. Develop data analysis strategies to account for spatial autocorrelation and directional flows in data from paired watershed studies.

Approach

1. A summary of statistical modeling, methodology and strategies used in ecological network settings and described in the peer-reviewed literatures of hydrology, wildlife management, fisheries, stream ecology, statistics and quantitative ecology will be produced. Methodologies and models that incorporate spatial and temporal autocorrelation, cumulative effects and directional flow will be targeted. We will also specifically search for any methods used in ecological network settings.

2. Several methods best suited to the research hypotheses of the Hinkle Creek Study will be identified and applied to data from this study. Strengths and weakness of these approaches will be identified and recommendations for future stream and watershed studies will be produced.

3. A statistical analysis strategy (e.g., models, methods) for integrating autocorrelation and flow information into data analysis will be developed for ecological questions from branched stream settings. We anticipate integrating methods from multiple fields and potentially developing new methods.