Hotspots of Landscape Change: Identifying Key Linkages between Water Quality and Land Development Patterns in Riparian Areas of the North Central Region

A proposal submitted to the U.S. Forest Service, North Central Research Station

Submitted By:

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February 1, 2002

Problem Statement: Changing patterns of land development, landownership and land use continue to alter the character and quality of landscapes in the North Central region. Average parcel size of privately owned land in the Lake States has been dropping over the past two decades, while vacation home and hobby farm development in previously rural, wooded and riparian areas is on the rise. Riparian areas in this Region face particularly acute pressure due to their desirable attributes for residential, commercial and recreational uses. For example, a 1996 study by the Wisconsin DNR found that shoreline development had increased an average of 216% on lakes in Northern Wisconsin between 1960 and 1995. These changes are often accompanied by unintended consequences, including degraded ecosystem health, reduced economic opportunities, depressed land value, and diminished recreational opportunities. Our research focuses on identifying and understanding some of the key relationships between land use and water quality interactions. Specifically, *we propose to examine the interactions between landscape change in riparian areas and lake water clarity*.

Objectives: The objective of this research is to investigate how the spatial distribution and intensity of land use in riparian areas impacts water clarity. Water clarity is a good proxy for water quality because the public values water clarity and associates high clarity with high quality. LANDSAT imagery will be used to assess historical changes in clarity (Kloiber et al., 2000). We will study these impacts over a 20-year timeframe and across a gradient of development intensities. The goal is to identify and quantify some of the key linkages between development in riparian areas and water quality. Our hypothesis is that the spatial distribution and nature of land development is as important as the absolute magnitude of development (e.g., total population or total acreage of residential/urban land) in altering lake water

quality

Approach: The first step of this study will be to identify riparian areas that span gradients of both water clarity and development pattern and intensity. To control for exogenous factors, the investigation will only focus on lakes. The selected set of study sites will include lakes with good water clarity in both "developed" and "undeveloped" areas, as well as lakes with poor water clarity in both "developed" and "undeveloped" areas. To control for additional factors, paired lakes with similar biochemical and morphological characteristics will be selected when feasible. The two lakes within each pair would have similar degrees of development but would vary with respect to changes in water quality.

We anticipate selecting 4-10 pairs of lakes. The lakes will be identified using a multi-faceted selection process. The first step involves identifying counties or lake regions that have undergone a range of land use and development changes. Data from the "Hot Spots of Landscape Change" study (FS-NC-4153-01-01) will be utilized, in conjunction with discussions with county land managers, to facilitate the identification of these sites. Population and housing density data from 1980 and 2000 will also be available from the Hotspots Study as an additional GIS data layer. A lakes GIS-layer will be overlaid with these layers to identify lakes that have experienced different rates of land use change and development over the 20-year period from 1980-2000. Finally, satellite imagery data from LANDSAT, along with supplemental water quality data, will be used to identify lakes that span the gradient of water quality. Research at the University of Minnesota Water Resources Center has demonstrated the ability to use LANDSAT imagery as an effective tool to assess trophic conditions in lakes (e.g., water clarity and chlorophyll levels). LANDSAT imagery acquired by the University of Minnesota covers the study area at regular intervals, dating back to 1975. This makes it possible to estimate water clarity throughout the past quarter century and evaluate changes. Supplemental water quality data will be used to corroborate interpretations from LANDSAT imagery and to establish causality of observed trends, to the extent possible.

The second step will be to identify factors responsible for or contributing to observed development patterns in the selected sites, through an analysis of zoning regulations, local CCR's (covenants, codes and restrictions) and other regulatory controls on historical land development in each watershed. To the extent possible, economic conditions will be assessed throughout the study period, and qualitative development histories of the selected lake sites will be prepared. Finally, we will examine a variety of multivariate statistical analysis techniques to analyze the relationships between land use and water clarity variables. Some of the predictors that we will examine include: physical site characteristics, land cover, lot size, land prices, house size, housing and population density, recreational use and development, septic systems, and distance to highways and urban centers. Land development models, such as the RESAC model developed at the University of Michigan, will be evaluated and used, if use can be justified by the preliminary evaluation (http://resac.gis.umn.edu/index.html).

Expected Results and Outcomes: Our goal is to identify the individual contributions or effects of different development and site quality attributes on water quality. *The outcome of this research will be the identification, quantification and evaluation of relationships between water clarity and various*

development patterns, factors and densities. This research will contribute to the North Central Research Station's Landscape Change and Riparian Landscapes Integrated Research programs through the development of strategies and tools that enhance our ability to plan for and respond to potential adverse consequences of landscape change in riparian areas.

The knowledge gained from this research will be valuable to communities and land managers who want to make land use decisions that have minimal impacts to water quality, but currently lack adequate information to do so. Our research will be a first step in addressing this issue through the identification of predictors and relationships between land use choices and water quality impacts. This information will assist landowners, local governments and public land managers in making better decisions about zoning regulations and land management practices in areas with riparian resources that promote "low-impact" development. We will disseminate the findings from this research through at least one peer-reviewed journal article and a web-based summary of the findings for a lay audience.

We anticipate that the results of this research will form the basis for a more involved future study that will focus on predicting where potentially significant water quality impacts in riparian areas may occur. While this study will focus on a set of lakes in the North Central region, the approach will be applicable to other regions of the country.

References:

Kloiber, S.M., T. Anderle, P.L. Brezonik, L. Olmanson, M.E. Bauer, and D.A. Brown. 2000. Trophic state assessment of lakes in the Twin Cities (Minnesota, USA) region by satellite imagery. *Arch. Hydrobiol. Ergebn. Limnol.* 85: 1-15.

Personnel and Roles:

Stephanie Snyder, North Central Research Station, St. Paul, MN. Contribution: Selection of study sites; facilitate acquisition of land-cover, water quality, and demographic data sets; participate in data analysis.

Larry Baker, Senior Fellow, Minnesota Water Resources Center, University of Minnesota. Contribution: Lead analysis of lake trophic status and compilation and interpretation of water quality data; collaborate on interpretation of land-cover change and water quality trends.

Mary Renwick, Senior Fellow, Minnesota Water Resources Center, University of Minnesota. Contribution: Conduct statistical analyses relating land development patterns and water quality.

Robert Potts, North Central Research Station, Rhinelander, WI. Contribution: Compile land-cover and population change data. Construct development history of selected lake sites. Facilitate creation and integration of GIS layers.

Study Time Frame: We anticipate that this study will have duration of 18-24 months, and will

commence in the spring of 2002.

Environmental Analysis Considerations

All of the work described in this study plan is covered under the categorical exclusion for research activities (7 CFR 1b.3(3) and FSH 1909.15 31.1a(3)). In addition, the research will not result in any extraordinary circumstances involving environmentally sensitive situations or conditions (FSH 1909.15 30.3 2). Finally, the research is not connected to or a source of significant cumulative impacts. The scoping required for all Forest Service actions has been documented and is on file.