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Eutrophication and Land Use

Lake Dillon, Colorado

With 67 Figures

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Preface

Nutrient enrichment (eutrophication) is a major theme in freshwater ecology. Some themes come and go, but the inevitable release of phosphorus and nitrogen that accompanies human presence seems to ensure that eutrophication will not soon become an outmoded subject of study. Eutrophication raises issues that range from the pressingly practical problems of phosphorus removal to the very fundamental ecological questions surrounding biological community regulation by resource supply. Although it is possible to take a reductionist approach to some aspects of eutrophication, the study of eutrophication is fundamentally a branch of ecosystem ecology. To understand eutrophication in a given setting, one is inevitably forced to consider physical, chemical, and biological phenomena together. Thus while eutrophication is the focus of our study of Lake Dillon, we have assumed that a broad base of limnological information is a prerequisite foundation.

Eutrophication of a lake can be studied strictly from a limnological perspective. If so, the nutrient income of the lake is quantified but the sources are combined within a black box whose only important feature is total loading. It is also possible, however, to treat the watershed and lake as equally important components of a hybrid system. In this case the nutrient sources must be dissected and their variability and dependence on key factors such as runoff must be quantified. In view of the abundant information on nutrient flux of watershed, it seems increasingly difficult to justify continued separate treatment of lakes and watersheds. In the Lake Dillon study, we have attempted to treat watershed analysis as comprehensively as we have limnological analysis, and thus to achieve some insight into land-water coupling.

As a subject of case history analysis, Lake Dillon has some especially interesting features. Many eutrophication studies deal with grossly polluted lakes. Lake Dillon, which would be unproductive (oligotrophic) if the watershed were uninhabited, was brought to a moderately enriched (mesotrophic) status in the 1970s by watershed development. Development was not accompanied by unplanned disposal of minimally treated waste, but rather by a wasteload allocation sufficiently stringent to require tertiary treatment for phosphorus at all four major plants within the watershed. Thus Lake Dillon is an example of eutrophication in the face of state-of-the-art point source technology. Because point sources are subject to tight control, a wide variety of dispersed sources and natural background account for major proportions of lake nutrient loading. Lake Dillon is also of special interest in that it receives extraordinarily high ratios of nitrogen to phosphorus in runoff, yet experiences an interval of pronounced nitrogen limitation in the mixed layer. This seems inconsistent with current theory, and is thus a major focus of attention in our analysis.

The Lake Dillon study was supported by funds from the United States Environmental Protection Agency under a Clean Lakes Grant (Section 314, Clean Water Act) and by the Northwest Colorado Council of Governments, from the towns of Breckenridge, Frisco, and Dillon; sanitation districts of Breckenridge, Copper Mt., Frisco, and Dillon-Silverthorne; the Denver Water Board, and the AMAX and Keystone Corporations. The project was administered by the Dillon Clean Lakes Steering Committee, whose members and their constituencies have been exceptionally supportive and helpful. We are especially indebted to the Committee's secretary, Mr. Tom Elmore, who has answered innumerable queries and solved many problems for us, and to the chairman of the Committee, Mr. Bruce Baumgartner, for his decisive leadership.

Analytical work was done by the University of Colorado Limnology Laboratory. Chemists for the project included Ms. Katherine Ochsner, Mr. Stephen Hamilton, Ms. Margaret Robbins, and Mr. Lewis Dennis, all of whom were dedicated to their work well beyond what we had a right to expect. The field crew, which performed its duties well many times under the most arduous conditions, included at various times Dr. Robert Epp, Mr. Steven Murray, Mr. Donald Morris, Jr., Mr. George Kling, and occasionally our chemists and Mr. Terry Carter of the Colorado Department of Health, who was also helpful in many other ways. Ms. Mary Marcotte did a skillful job of preparing the manuscript and Mr. George Kling did the same for the drafting. We are grateful to Ms. Heidi Thompson for counting the zooplankton and to Dr. R. Dufford for confirming the diatom identifications.

We thank the Denver Water Department, Ms. Jerry Vest and other members of the Summit County Planning Department, the Summit County Engineering Department, Mr. Barry Sheakley of the U.S. Forest Service's Dillon Ranger District, and Mr. Wesley Nelson of the Colorado Division of Wildlife for supplying us with various kinds of data. We are grateful to the wastewater treatment plant operators and especially to Mr. Buck Wenger of the Snake River Wastewater Treatment Plant, where our field crews did a considerable amount of sample processing. We also appreciate occasional volunteer contributions from Dr. Thomas Frost, Dr. Suzanne Levine, and Ms. Claudia Cressa, all of the University of Colorado Limnology Laboratory.

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