HYDROLOGIC AND GEOMORPHIC CONTROLS ON PARTICULATE CONCENTRATIONS IN ICHAWAYNOCHAWAY CREEK, A BLACKWATER COASTAL PLAIN STREAM

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REFERENCE: Proceedings of the 1999 Georgia Water Resources Conference, held March 30-31, 1999, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, University of Georgia, Athens, Georgia.

Abstract. Examining controls on particulate concentrations in streams is an important step in understanding stream structure and function. In Coastal Plain streams, organic particles derived from floodplain soils are an important food source for aquatic life; inorganic particle concentrations can be indicators of watershed disturbance. Since 1993, we have been examining organic and inorganic particle concentrations in Ichawaynochaway Creek, a 5th order blackwater tributary of the lower Flint River. Monthly samples have been collected during stable flow periods at 7 stations ranging from near the headwaters to the confluence with the Flint River. Our study indicates that geomorphology and hydrology interact to control particle concentrations. Concentrations of all particles were greatest during floods. Areas with well-developed floodplains appear to be source areas for organic particles. In the development of regional conservation programs, floodplain swamp forests may merit special consideration to protect the trophic base of stream communities. In addition, management actions or water allocation formulae that systematically reduce the annual period of floodplain inundation may reduce organic particle transport from floodplains. Reductions in organic concentrations would lower food availability to support aquatic life.

INTRODUCTION

Background

As ecosystems, streams have several unique characteristics (Vannote et al. 1980, Minshall et al. 1983). The linear nature of streams promotes maximum interaction with the adjacent landscape, and organic matter and other materials from terrestrial sources are important resources for stream communities. In addition, stream communities are longitudinally linked by the flow of water so that material exported from upstream areas may be an important resource downstream. However, because of their linear nature streams are susceptible to human disturbance (i.e. pollution), and the effects of human activities may have impacts far removed from their point of origin.

Coastal plain streams are unusual because extensive riparian swamp forests often extend laterally from stream margins. Seasonally, during floods, these forests may contribute substantial quantities of organic matter to streams (e.g. Cuffney 1988, Meyer and Edwards 1990). Since a major food resource in coastal plain streams is transported organic matter (e.g. Wallace et al. 1987), predictable pulses of organic matter from floodplain forests may be important in maintaining aquatic productivity. Streamside forests provide additional benefits by stabilizing soils and minimizing erosion during floods. Streamside forests also absorb nutrient and sediment runoff from intensively managed uplands (e.g. Childers and Gosselink 1990).

Research Objectives

To date, most studies on riparian control of particle transport in streams have focused on headwaters or stream segments (e.g. Cuffney 1988, Dosskey and Bertsch 1994). The influence of riparian geomorphology on particle concentration and size distribution has been little studied from a whole stream perspective. The purpose of this research was to examine long-term trends in particle transport in Ichawaynochaway Creek, a Gulf Coastal stream. We hypothesized that segments of the stream with well-developed floodplains would act as sources of organic matter to the larger stream system. We also hypothesized that inorganic particle concentrations would be generally low, because a largely intact riparian corridor occurs along the length of the stream.

Significance to Conservation Issues

As human populations have increased, the geomorphology, hydrology, and water quality of most streams have been altered through municipal development, agriculture, silviculture, and channel modification. As a result, very few unaltered streams remain in North America (Benke 1990, Dewberry and Pringle 1994). Efforts at river protection and conservation have lagged behind development and, to date have largely focused on water quality and protection of "pristine" reaches or river segments (Palmer 1993, Dewberry and Pringle 1994). While clean water and protection of river segments are important, alone they may not preserve the ecological integrity of streams. There is growing recognition that protecting natural hydrologic regimes, or developing managed hydrologic regimes that simulate natural cycles of flooding, are critical in preserving stream ecosystems (e.g.

Stanford et al. 1996). Hydrologic management must occur on a whole basin scale.

The lack of whole basin perspective in river conservation can be attributed to a lack of information. Until recently, few studies of structure and function of whole stream ecosystems existed (e.g. Dewberry and Pringle 1994). Since stream segments are linked both longitudinally (headwaters to large rivers) and laterally (to uplands and riparian zones) the strategy of protecting segments is destined to be unsuccessful. Implementing conservation programs on a basin-wide scale is essential. Studies on origins of materials and their relation to riparian geomorphology and natural hydrologic variation are essential in developing a broad basin-oriented view of stream ecosystems.

SITE DESCRIPTION

Ichawaynochaway Creek is a major tributary of the lower Flint River, on the Gulf coastal plain of southwest Georgia. Ichawaynochaway Creek is a blackwater stream originating in an extensive swamp and wetland system. It flows southward approximately 100 km crossing an agricultural and forested landscape before discharging into the Flint River. An intact riparian zone occurs along most of the stream that is composed of flood tolerant hardwoods, bald cypress (*Taxodium distichum*), and red cedar (*Juniperus silicicola*). Average stream gradient is 6 m/km in the headwaters and 1 m/km downstream. The stream can be divided into 2 segments based on regular variation in riparian geomorphology. In the upstream segment, the width of the floodplain and associated riparian wetlands increases down stream (Figure 1). In the downstream segment floodplain width declines and the channel consists of alternating constrained and unconstrained reaches. The overall effect is a decrease in the floodplain to channel ratio (i.e. riparian index, Figure 1) with increasing distance downstream.

Average annual discharge at a gauging station approximately 69 km downstream from the headwaters is 22 m^3/s. Average discharges range from a low of 11.6 m^3/s in September to a peak 38.4 m^3/s in March (1905-1997, Stokes and McFarland 1998).

METHODS

Baseflow samples were collected monthly (July 1993-December 1997) at 7 sites ranging 10-96 km downstream from the headwaters. In the field, 20-30 L of water were poured through nested sieves (250μm, 43μm). Material collected was rinsed into plastic bottles, stored on ice and transported to the laboratory for analysis. Water passing through sieves was also collected. In the laboratory, each fraction was filtered onto preweighed glass fiber filters, dried, weighed, ashed, and reweighed to determine organic and inorganic content. This procedure quantified particle concentrations in three fractions: large (>250μm), medium (43-250μm), and small (<43μm).

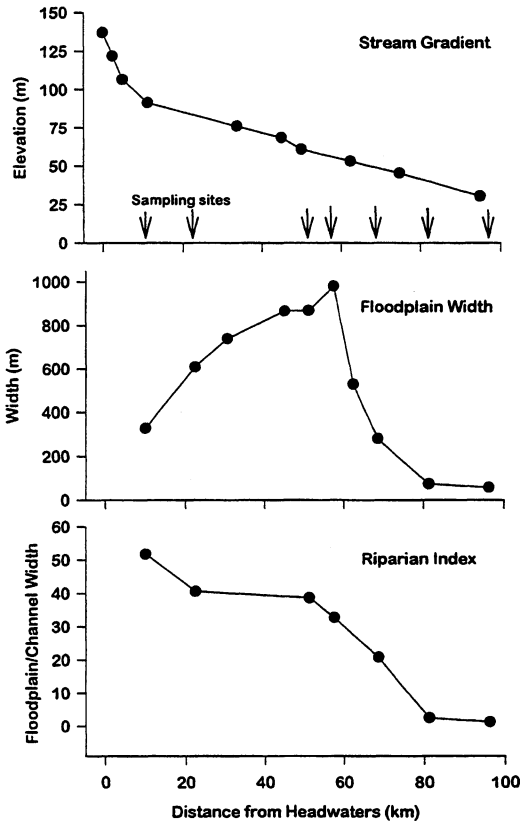

Figure 1. Physical characteristics of Ichawaynochaway Creek.

RESULTS

Averaged for the whole stream, total particulate organic matter (POM) concentrations ranged from 1-5 mg/L (Figure 2). Total particulate inorganic matter (PIM) concentrations ranged from 1-12 mg/L. Particle concentration was under strong hydrologic control. Highest concentrations were observed during high flow periods. This was especially evident from the summer of 1994 through the spring of 1995, when southwest Georgia received substantially greater than average rainfall. Lowest concentrations generally occurred during late summer and autumn baseflows.

Seasonally, the spatial distribution of POM in Ichawaynochaway Creek was under strong geomorphic control (Figure 3). POM concentrations were strongly correlated with riparian development (i.e. floodplain to channel ratio). Consistently greater concentrations of POM were observed in the upper portion of the stream where riparian development was greatest. POM concentrations were also sensitive to hydrologic conditions, generally higher concentrations were observed at all sites during high flow periods, typically January through June. However, within the stream the relationship of POM concentration and riparian development was consistent regardless of hydrology.

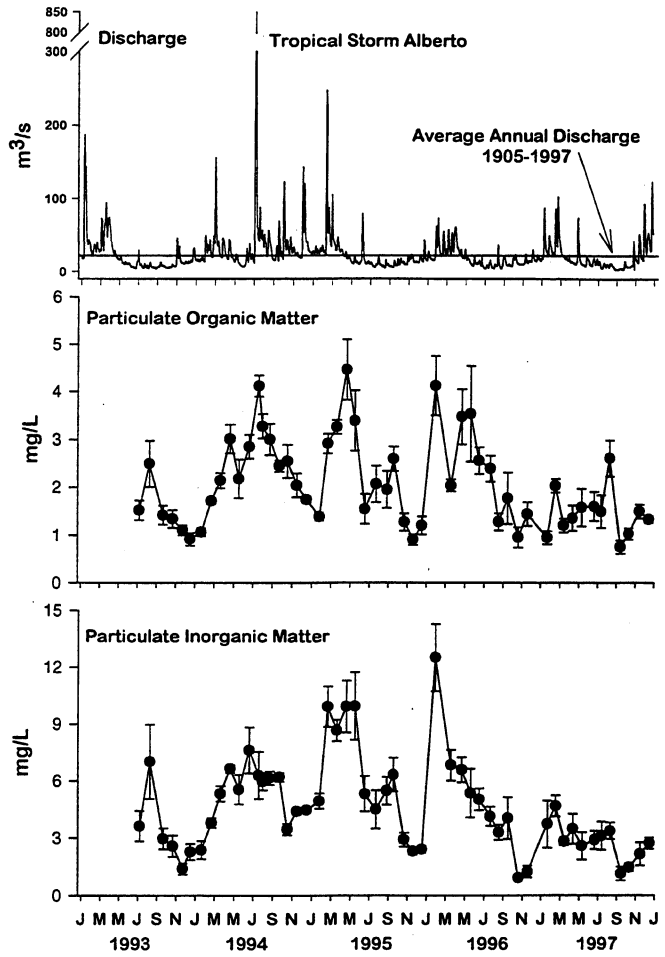

Figure 2. Discharge and particle concentrations in Ichawaynochaway Creek.

PIM concentrations were not strongly correlated with riparian development (data not shown). Generally highest concentrations were measured during high flow periods, often at sites in the mid reaches of Ichawaynochaway Creek.

Transport was dominated by the small particles (1-43 μm), which accounted for ~75% of material in transport (data not shown). For both POM and PIN, the distribution of particles was influenced by hydrology. The portion of small particles increased (~80 – 85%) during the record runoff that occurred from July 1995 through May 1995.

DISCUSSION

Particle Transport

Consistently higher POM concentrations in upstream areas indicate that headwater swamps and riparian areas with broad floodplains are important source areas for organic matter in transport. Declines downstream suggest that organic matter is being metabolized or retained in upstream areas and not replaced by instream or riparian sources. Regional hydrology also appears to be an important factor controlling organic matter transport. As the stream channel changes during extended wet and dry periods, organic matter concentrations respond accordingly. During dry periods, concentrations decline as the channel shrinks. During wet periods, concentrations increase as the channel expands and organic matter is scavenged from inundated riparian areas. It has been proposed that alternate drying and flooding stimulate nutrient release and organic matter decomposition (Junk et al. 1989). Partial decomposition of stored organic matter on floodplains during dry periods may promote organic export during subsequent flood cycles, enhancing aquatic productivity (Junk et al. 1989). Thus, controls on POM appear to be hierarchical. At the regional scale, hydrology (i.e. magnitude of runoff) is the dominant influence while, at the reach scale, riparian geomorphology controls POM availability.

In contrast, PIM concentrations, while under hydrologic control, did not show a strong relationship to riparian development. Others factors, including human land use likely influence PIM transport. Compared to other studies, the PIM concentrations we measured were relatively low, within the range reported for a boreal river system with minimal human land use (Naiman 1982). We attribute the low PIM concentrations to the intact streamside forest adjacent to most of the stream. Loss of streamside forests has been correlated

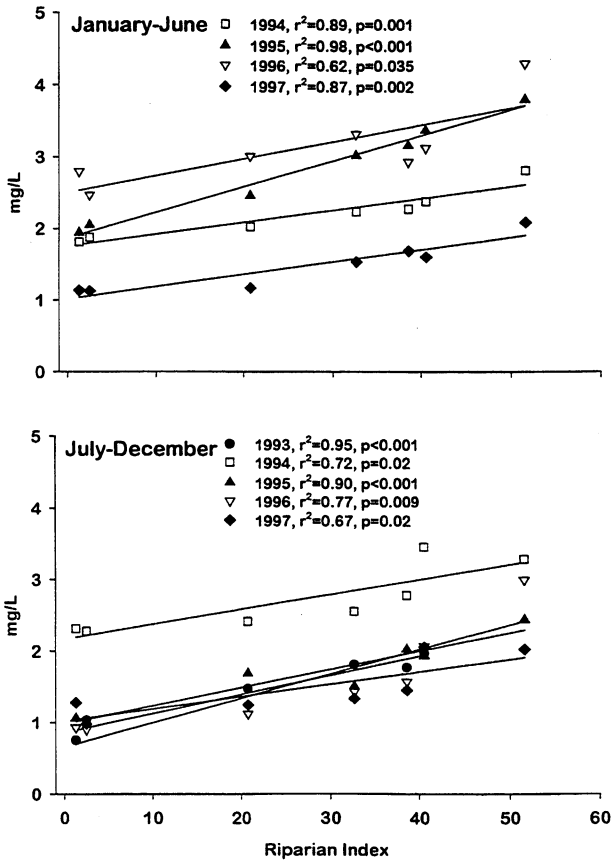

Figure 3. POM concentration versus riparian index for Ichawaynochaway Creek.

with elevated sediment concentrations in streams (Childers and Gosselink 1990).

Small Particles

The dominance of small particles (< about 50μm) appears to be a universal feature of streams. Similar patterns have been reported in boreal (Naiman 1982), northern temperate (Sedell et al. 1978), southern prairie (Hill et al. 1992), southern Appalachian (Wallace et al. 1982), and Atlantic coastal plain streams (Cudney and Wallace 1980).

Summary

Despite agricultural and municipal development on its catchment, Ichawaynochaway Creek remains a relatively undisturbed stream. Both headwater swamps and riparian forests along the Creek and its major tributaries remain largely intact. The results of this research suggest that headwater swamps and areas with extensive riparian forests are an important source of organic matter to coastal plain streams. The roles of swamps and riparian forests have long been appreciated in floodwater storage, in reducing non-point source pollution, and as wildlife habitat. However, our research also suggests that export of organic matter from riparian areas is critical in maintaining the trophic base of aquatic communities. In the development of regional conservation programs, floodplain swamps and forests deserve special consideration and protection. Also, water allocation formulae and water resource policy need to recognize the benefits of natural flood cycles. Protection of riparian areas and flood cycles may be critical for the maintenance of instream biological community structure and productivity. Preserving streamside forests has the additional benefit of minimizing sediment runoff from intensively managed uplands.

ACKNOWLEDGMENTS

Jean Brock, Mark Drew, Frankie Hudson, Tara Hannon, Paula Houhoulis, Jeannine Ott, Matt Lauck, and Brad Taylor assisted with the laboratory and fieldwork. We thank Chris Craft for commenting on this paper. The R.W. Woodruff Foundation and J. W. Jones Ecological Research Center provided funding.

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