Relations between Retired Agricultural Land, Water Quality, and Aquatic-Community Health, Minnesota River Basin

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The relative importance of agricultural land retirement on water quality and aquatic-community health was investigated in the Minnesota River Basin. Eighty-two sites, with drainage areas ranging from 4.3 to 2200 km², were examined for nutrient concentrations, measures of aquatic-community health (e.g., fish index of biotic integrity [IBI] scores), and environmental factors (e.g., drainage area and amount of agricultural land retirement). The relation of proximity of agricultural land retirement to the stream was determined by calculating the land retirement percent in various riparian zones. Spearman's rho results indicated that IBI score was not correlated to the percentage of agricultural land retirement at the basin scale (p = 0.070); however, IBI score was correlated to retired land percentage in the 50- to 400-m riparian zones surrounding the streams (p < 0.05), indicating that riparian agricultural land retirement may have more influence on aquatic-community health than does agricultural land retirement in upland areas. Multivariate analysis of covariance and analysis of covariance models indicated that other environmental factors (such as drainage area and lacustrine and palustrine features) commonly were correlated to aquatic-community health measures, as were in-stream factors (standard deviation of water depth and substrate type). These results indicate that although agricultural land retirement is significantly related to fish communities as measured by the IBI scores, a combination of basin, riparian, and in-stream factors act together to influence IBI scores.

Stream conditions are influenced by interactions among physical and chemical factors. In the Minnesota River Basin, the loss of riparian vegetation and natural land cover has reduced habitat, modified hydrologic conditions, and changed water quality (Stark et al., 1996; Stauffer et al., 2000; Lee et al., 2001). Agricultural activities in general have resulted in widespread degradation of water quality (Capel et al., 2008). Three important spatial scales that influence physical, chemical, and biological conditions are basinwide conditions, riparian (area adjacent to the stream) conditions, and in-stream conditions. Numerous researchers have investigated the relation of land use to water quality at different spatial scales (Silva and Williams, 2001; Bolstad and Swank, 1997; King et al., 2005) and the spatial arrangement of land cover on stream ecosystems (O’Neill et al., 1997). More specifically, some investigators have compared land cover within certain distances from a stream or sampling site (Omernik et al., 1981; Schuft et al., 1999; Sponseller et al., 2001).

The Minnesota River Basin, located primarily in the State of Minnesota (Fig. 1), is part of the Midwest Corn Belt, one of the most productive and intensively managed agricultural regions in the world. Agricultural activities have changed landscapes throughout the Midwest, and streams in the Minnesota River Basin commonly have diminished aquatic resources due to intense physical and chemical perturbations (Stauffer et al., 2000). To address concerns about degradation of agricultural streams, Federal and State of Minnesota programs have encouraged agricultural land retirement through the Conservation Reserve Program (CRP) (Lant, 1991), the Reinvent in Minnesota Program (Korczak and Gran, 1986), and the Conservation Reserve Enhancement Program (Smith, 2000). In the Minnesota River Basin, agricultural land taken out of production through conservation programs typically is planted in native grasses. Retired agricultural land cover may be important to water quality, aquatic habitat, reduction of sediment, and reduction of overland runoff.