

Original Research Article

Water quality change and habitat potential in riparian ecosystems

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ABSTRACT

Riparian ecosystems play a vital role in providing ecosystem services that include habitat support and protection of water quality. This study assessed the role of riparian ecosystems along the lateral and longitudinal dimensions of the watershed system. A reach-scale assessment, spatial analysis using GIS, and a dynamic simulation of interactions were used to evaluate riparian dynamics in the Westfield River Watershed of Massachusetts. Riparian and riverine characteristics (slope, soils, and flow regime), disturbance regimes (land use and bank impairment), bird habitat suitability, available niches for wildlife, and vegetation biomass were found to vary along the longitudinal dimension of the watershed. Habitat potential (suitability to sustain a species) declined in general (trend) with riparian distance and a maximum potential was observed at an intermediate level. Dynamic simulation was performed using the STELLA model to quantify interactions between different reaches, land conditions, and land use to quantify soil loss (RUSLE equation) and spatial accumulation. Simulations showed a spatial influence in sediment transfer and loading into the stream. Policy simulations on land use in specific riparian locations showed a significant impact of urbanization on the water quality of the river. Significant reductions in soil loss (3%–48% decrease, depending on the spatial location of the practice) could be achieved through implementation of Best Management Practices (BMPs). Optimal placement of BMPs and conservation efforts in the riparian zone could be used to protect habitat potential and water quality of the watershed.

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1. Introduction

Riparian zones are transitional areas between terrestrial and aquatic ecosystems (Brooks et al., 1997) that are vital to the health of watershed systems. Riparian zones provide numerous functions that are beneficial to human populations and ecosystems. The riparian zones are

characteristic of both lateral (riparian gradient) and longitudinal (riverine continuum) dimensions. In the case of lateral gradients, riparian zones (Hession et al., 2000) provide habitat functions to support a wider variety of species (Naiman and Decamps, 1997). In watershed systems, riparian areas often account for a small portion of the spatial area but are ecologically important because of the various ecosystem services they provide (Baker et al., 2006).

The riparian component of watershed ecosystems is often valued higher than the upland areas (Bollman, 1984). Ecosystem services provided by these zones include

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protecting water quality (Novak et al., 2002; Correll, 1996), flood control, ground water recharge, habitat, and corridor functions for a variety of organisms (Rosenberg et al., 1997; Naiman et al., 1993). Healthy riparian zones also reduce stream bank erosion, and act as natural detention areas during flooding, thereby allowing groundwater recharge and dispersion of energy from flood events (Kiffney et al., 2003; Sweeney et al., 2004; Vidon and Hill, 2004; Dwire and Lowrance, 2006). A healthy riparian system is critical in sediment and river dynamics.

Despite their importance to environmental sustainability, riparian ecosystems are impacted by urbanization, agricultural and forestry operations, and intensity of upland uses (Cabezas et al., 2009; Snyder et al., 2003). Urban and agricultural activities continue to degrade streams and riparian areas worldwide (Allan, 1995). Almost two-third of the riparian acreage in the USA is converted to non-forested land uses (Swift, 2007). Studying these fragile areas is important for the assessment and protection of ecosystem services in watersheds (Jones et al., 2010).

While the extent of riparian functions is well studied in the literature, there is a need for modeling of the role of riparian zones in providing habitat services and dynamic changes in riverine water quality (Cabezas et al., 2010). The roles of riparian ecosystems in the protection of wildlife habitat and aquatic ecosystems, and in flood mitigation, are increasingly being recognized in watershed modeling and management. In this study, we model the riparian functions along lateral and longitudinal dimensions using GIS, field observations, and dynamic modeling. This information is used in assessing the efficiency of policies that target protection of water quality and habitat potentials of riparian ecosystems.

The general objective of this study was to evaluate the riparian attributes along the lateral and longitudinal (urban and rural) dimensions of the Westfield River and to model the dynamics in sediment loading to identify alternative policy opportunities. Onsite assessment in river reaches, GIS analysis of the riparian zone, and a dynamic

riparian model of sediment dynamics was used for the assessment of policy effectiveness. The study is unique in evaluating riparian dynamics under alternative spatial conservation policies. Specific objectives of this study were: (i) to study riparian ecosystems in their lateral and longitudinal dimensions of the river; (ii) to model the dynamic, spatial impacts of riparian land use on water quality; and (iii) to develop strategies to protect riparian habitats to preserve their water quality enhancement functions. Hypotheses that were tested included: (i) spatial variations along the lateral and longitudinal dimensions of a stream significantly influence the habitat and water quality improvement functions of riparian ecosystems; (ii) land use in riparian zones has significant impacts on sediment loads into the riverine system; and (iii) targeted Best Management Practices (BMPs) in areas with urban and rural land uses results in a significant reduction in sediment loads.

Dynamic analysis of riparian land use impacts on water quality and habitat changes, along varying spatial and temporal dimensions, is limited in watershed literature. In this study, we evaluated riparian zones of distinct reaches to identify differences in physical and habitat conditions. The reaches represented two different disturbance regimes in the watershed and were evaluated for habitat, topographical characteristics, and biodiversity. A comparative analysis was used to evaluate the role of these riparian characteristics and to identify supporting riparian characteristics. The dynamic model of changes in water quality in the riparian ecosystem was useful in the development of spatial policies to manage ecosystem services.

2. Methodology

The Westfield River Watershed of western Massachusetts (Fig. 1) drains 1339 km² through 1368 km of rivers, streams and brooks. There are 1700 ha of lakes and ponds in the watershed and 28 towns occupy the watershed. The watershed contains an estimated population of 85,000

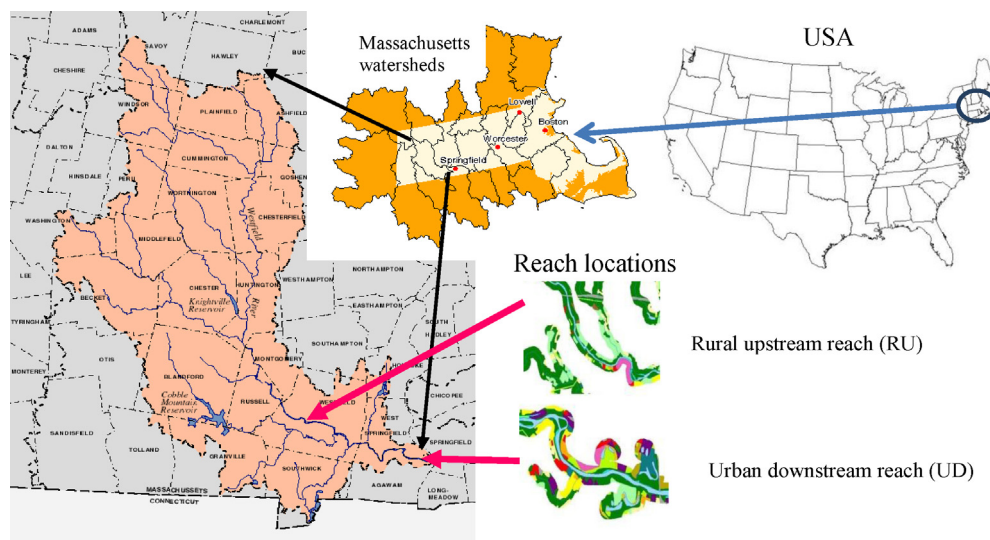


Fig. 1. Westfield River Watershed (USA) and sampled reaches.

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