Urban Ecosyst (2015) 18:293–320
DOI 10.1007/s11252-014-0384-x

Attachment R

Influence of urbanization on a karst terrain stream and fish community

Kristy A. Kollaus · Kenneth P. K. Behen · Thomas C. Heard · Thomas B. Hardy · Timothy H. Bonner

Published online: 29 June 2014

Abstract Effects of catchment urbanization described as the urban stream syndrome generally result in an altered fish community with headwater stream fish communities particularly vulnerable to changes associated with urbanization. In this study, we considered how the fish community in a Central Texas headwater karst stream changed with catchment urbanization. Paleohistory and a narrative on urbanization within the upper San Marcos River were compiled and qualitatively related to historical fish changes from 1880 to 2011 to test predictions of the urban stream syndrome. Our predictions of decreases in native fish community and species abundances were largely unsupported despite 170 years of urbanization, specifically anthropogenic alterations to instream and catchment habitats, water quantity and water quality, stream morphology, and introduced species. Overall, the upper San Marcos River supports a persistent (>60 %) fish community through time with observed native species declines and extirpations not attributed solely to urbanization within the catchment. As such, we conclude that upper San Marcos River is largely an exception to the urban stream syndrome, which we attribute to two mechanisms; 1) paleohistory of the upper San Marcos River suggests a dynamic stream system with decreasing stream flow and increasing water temperatures since the last glacial maximum, and 2) water quantity of the San Marcos River is much greater than water quantity of other headwater streams used to assess urban stream syndrome. Nevertheless, the lower portion of the upper San Marcos River is indicative of an altered system, in both habitat and fish community, and represents a target area for rehabilitation.

Keywords Urbanization · Karst stream · Historical narrative · Long-term fish community changes

K. A. Kollaus (✉) · T. C. Heard · T. B. Hardy
The Meadows Center for Water and the Environment, Texas State University – San Marcos, 601 University Drive, San Marcos, TX 78666, USA
e-mail: KK26@txstate.edu

K. P. K. Behen · T. H. Bonner
Department of Biology/Aquatic Station, Texas State University – San Marcos, 601 University Drive, San Marcos, TX 78666, USA

have altered the fish community within this reach (Behen 2013). More consistent with historical conditions, the upper 2.5 km of the San Marcos River is characterized by dense aquatic vegetation and coarse substrates over a broader channel with shallower depths and higher current velocities, whereas the lower 6 km is characterized by a stream channelized into the underlying Taylor Marl Clay with increased depths and slower current velocities and a general absence of aquatic vegetation. We attributed these changes to three likely factors: 1) sediment degradation downstream from Cape's Dam (Brandt 2000), which excludes necessary fine sediments for aquatic vegetation establishment; 2) the backwater effect of Cumming's Dam, creating unnaturally deep water habitats; and 3) nutrient enrichment from a fish hatchery and waste water treatment plant resulting in eutrophication, decreased water clarity, and reduced light penetration, especially in the deeper waters and slower current velocities created by the backwater effect (Groeger et al. 1997; Santucci et al. 2005). Other factors, such as stream shading and channel incision, likely contribute to decreased aquatic vegetation (Kurtz et al. 2003). Within this reach, lentic tolerant species are predominant (e.g., *Lepomis* spp.), whereas fluvial specialists species (e.g., Burrhead Chub and Guadalupe Darter), endemic headwater species (e.g., and Fountain Darter and Guadalupe Roundnose Minnow), and downstream riverine species (i.e., Red Shiner) are rare or presumed extirpated. Similar fish community changes due to low head dams are well documented and have been attributed to altered temperature and habitat preferences (Walters et al. 2005; Meador et al. 2005), increased turbidity from eutrophication and suspended sediments (Walters et al. 2009), and fragmentation from source populations (Catalano et al. 2007).

Ecological rehabilitation attempts to recover elements of the natural range of ecosystem processes within degraded systems, such as urbanized streams (Hughes et al. 2014), and urbanized streams provide unique opportunities to test aspects of rehabilitation theory and practice (Paul and Meyer 2001). Rehabilitation approaches in urban streams include improvements to hydromorphology (Niezgoda and Johnson 2005) with removal of low head dams suggested as a potential mechanism for restoring the natural dynamic state of a stream channel and corresponding ecological processes (Doyle et al. 2005). Low head dam removal increases bed sloping often resulting in reduced water depths and increased current velocities (Hart et al. 2002). Shallower depths and more heterogeneous current velocities reduce water retention time and therefore nutrient accumulation and concentration, increase water clarity, and increase sedimentation transport (Bednarek 2001), thus leading to increases in vegetation growth (Rybicki et al. 2001). The lower reach of the upper San Marcos River offers an opportunity to test rehabilitation theory related to low head dams. We predict the proposed removal of two low head dams (i.e., Capes Dam and Cummings Dam) would restore the natural dynamic state of the stream channel including reduced depths, increase current velocities, heterogeneous substrates, and vegetation, thereby expanding current distributions of several endemic species that are associated with more heterogeneous habitats. However, expanding rehabilitation efforts beyond the lower reach and into the catchment is likely needed to mitigate continuing urbanization (Hughes et al. 2014; Violin et al. 2011). Even with proper management, improvement practices, and rehabilitation efforts, the upper San Marcos River likely cannot sustain its unique fish community and associated habitat without the continued supply of groundwater from the Edwards Aquifer.

Acknowledgments Funding for this study was provided by American Recovery and Reinvestment Act (ARRA). We thank S. Curtis, C. Thomas, and several other Texas State University graduate and undergraduate students for their assistance in the field. Sampling permits were granted by Texas State University-San Marcos (IACUC 06-0620_802), Texas Parks & Wildlife Department (Permit SPR-0601-159; issued to Bonner, T), and United States Fish and Wildlife Service (TE236730-1, issued to Bonner, T).