J. N. Am. Benthol. Soc., 2005, 24(3):585–587
© 2005 by The North American Benthological Society

Urbanization and stream ecology: an introduction to the series

JACK W. FEMINELLA[1]

Department of Biological Sciences, 331 Funchess Hall, Auburn University, Auburn, Alabama 36849-5407 USA

CHRISTOPHER J. WALSH[2]

Cooperative Research Centre for Freshwater Ecology, Water Studies Centre, and School of Biological Sciences, Monash University, Victoria 3800, Australia

Half of the world's population now lives in urban centers (Cohen 2003); as this proportion increases over time, local and global environmental impacts of urban areas also increase (McGranahan and Satterthwaite 2003). The nature and magnitude of urbanization impacts on streams and rivers have received little attention from ecologists until only recently, despite mounting international concerns about unsustainable resource use and pollution generation from urban centers (Walsh 2000, Paul and Meyer 2001). The extent of urbanization impacts on aquatic ecosystems likely is growing faster than the rate of urban population growth because advances in communications and the increased desire for personal green space often promote decentralization and urban sprawl (McGranahan and Satterthwaite 2003). Typically, such landscape change occurs from conversion of forest and rural land to residential, municipal, and commercial uses as the human population and its demand for land increases (Wear and Bolstad 1998, Wear and Gries 2002), particularly near water bodies.

Given the burgeoning problems of urbanization and the growing interest in understanding the interactions between urban/urbanizing landscapes and lotic systems, the Symposium on Urbanization and Stream Ecology (SUSE) was held at the University of Melbourne, Australia, in December 2003. The symposium had 3 aims: 1) to coalesce and synthesize current knowledge of the effects of urban land use on stream ecosystems; 2) to examine priorities and potential for stream restoration in urban catchments; and 3) to identify knowledge gaps that may guide future ecological research within urban catchments.

The following series of papers in this issue of J-NABS contains 9 papers presented at SUSE, and a synthesis paper (Walsh et al. 2005b) of these studies and other recent work. Each paper in the series makes a significant contribution to our general understanding of the consequences of urbanization on stream ecosystems. Four papers (Grimm et al. 2005, Groffman et al. 2005, Harbott and Grace 2005, Meyer et al. 2005) break ground on documenting effects of urbanization on stream ecosystem function, focusing on urban stream impacts in the southwestern, northeastern, and southeastern USA (Grimm et al. 2005, Groffman et al. 2005, Meyer et al. 2005, respectively), and in southeastern Australia (Harbott and Grace 2005). Three papers describe effects of urbanization on stream fauna: Roy et al. (2005) and Morgan and Cushman (2005) report on urban impacts to fish assemblages in southeastern and northeastern USA streams, respectively, whereas Serena and Pettigrove (2005), for the first time, document impacts of urbanization on the abundance and distribution of platypus (*Ornithorhynchus anatinus*) populations in southeastern Australia streams. Walsh et al. (2005a) and Booth (2005) present two perspectives on urban stream restoration. The prospects for restoration are explored further and directions for future research are discussed by Walsh et al. (2005b).

Meyer et al. (2005) introduce the concept of the ''urban stream syndrome'', which describes the consistent patterns of physicochemical and biological degradation to stream conditions associated with urban land use; this concept aptly summarizes the theme of the series. Hydrologic alteration is perhaps the most obvious and consistent symptom, if not the cause, of the syndrome. Roy et al. (2005) and Booth (2005) argue that hydrological metrics are reliable indicators of urban impacts on stream ecosystems. Both papers identify the increased frequency of high flows (stream ''flashiness'') following small rain

[1] E-mail addresses: feminjw@auburn.edu
[2] chris.walsh@sci.monash.edu.au

events as a fundamental agent of change to the urban hydrograph caused by conventional stormwater systems, which drain surface water quickly from impervious areas of catchments. Walsh et al. (2005a) explore this theme further, arguing that retaining stormwater from small rain events in the catchment for infiltration, reuse, or evapotranspiration may accrue large instream ecological benefits. In addition to hydrologic flashiness, Roy et al. (2005) report that prolonged low-flow conditions in urban streams also can promote shifts in stream biota.

Urban streams often show higher nutrient concentrations and less efficient nutrient uptake rates than native, unaltered streams (Meyer et al. 2005, Grimm et al. 2005), although Groffman et al. (2005) show that organic debris dams in urban streams can act as hot spots for denitrification. Harbott and Grace (2005) describe shifts in organic C bioavailability across streams of contrasting urbanization, and also document the use of bacterial extracellular enzymatic activity as an indicator of change in stream function along the urbanization gradient. The relative importance of nutrient retention in the catchment vs instream retention remains a critical knowledge gap, which resonates in the discussion of the potentially greater ecological benefits of redesigning upland drainage systems compared with traditional instream or near-stream restoration approaches (Booth 2005, Walsh et al. 2005a).

Last, Walsh et al. (2005b) identify that future research addressing such questions will require a broadening of stream ecology to integrate with other, diverse disciplines, including those involving socioeconomic and political dimensions. Indeed, the need for stream ecology and ecologists to help guide urban landuse development to maximize stream ecosystem values and services has never been greater nor more dire (Pickett et al. 2001, Palmer et al. 2004).

Literature Cited

BOOTH, D. B. 2005. Challenges and prospects for restoring urban streams: a perspective from the Pacific Northwest of North America. Journal of the North American Benthological Society 24:724–737.

COHEN, J. E. 2003. Human population: the next half century. Science 302:1172–1175.

GRIMM, N. B., R. W. SHEIBLEY, C. L. CRENSHAW, C. N. DAHM, W. J. ROACH, AND L. H. ZEGLIN. 2005. N retention and transformation in urban streams. Journal of the North American Benthological Society 24:626–642.

GROFFMAN, P. M., A. M. DORSEY, AND P. M. MAYER. 2005. N processing within geomorphic structures in urban streams. Journal of the North American Benthological Society 24:613–625.

HARBOTT, E. L., AND M. R. GRACE. 2005. Extracellular enzyme response to bioavailability of dissolved organic C in streams of varying catchment urbanization. Journal of the North American Benthological Society 24:588–601.

MCGRANAHAN, G., AND D. SATTERTHWAITE. 2003. Urban centers: an assessment of sustainability. Annual Review of Environment and Resources 28: 243–274.

MEYER, J. L., M. J. PAUL, AND W. K. TAULBEE. 2005. Stream ecosystem function in urbanizing landscapes. Journal of the North American Benthological Society 24:602–612.

MORGAN, R. P., AND S. F. CUSHMAN. 2005. Urbanization effects on stream fish assemblages in Maryland, USA. Journal of the North American Benthological Society 24:643–655.

PALMER, M., E. BERNHARDT, E. CHORNESKY, S. COLLINS, A. DOBSON, C. DUKE, B. GOLD, R. JACOBSON, S. KINGSLAND, R. KRANZ, M. MAPPIN, M. L. MARTINEZ, F. MICHELI, J. MORSE, M. PACE, M. PASCUAL, S. PALUMBI, O. J. REICHMAN, A. SIMONS, A. TOWNSEND, AND M. TURNER. 2004. Ecology for a crowded planet. Science 304:1251–1252.

PAUL, M. J., AND J. L. MEYER. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics 32:333–365.

PICKETT, S. T. A., M. L. CADENASSO, J. M. GROVE, C. H. NILON, R. V. POUYAT, W. C. ZIPPERER, AND R. COSTANZA. 2001. Urban ecological systems: linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. Annual Review of Ecology and Systematics 32:127–157.

ROY, A. H., M. C. FREEMAN, B. J. FREEMAN, S. J. WENGER, W. E. ENSIGN, AND J. L. MEYER. 2005. Investigating hydrological alteration as a mechanism of fish assemblage shifts in urbanizing streams. Journal of the North American Benthological Society 24:656–678.

SERENA, M., AND V. PETTIGROVE. 2005. Relationship of sediment toxicants and water quality to the distribution of platypus populations in urban streams. Journal of the North American Benthological Society 24:679–689.

WALSH, C. J. 2000. Urban impacts on the ecology of receiving waters: a framework for assessment, conservation and restoration. Hydrobiologia 431: 107–114.

WALSH, C. J., T. D. FLETCHER, AND A. R. LADSON. 2005a. Stream restoration in urban catchments through redesigning stormwater systems: looking to the

catchment to save the stream. Journal of the North American Benthological Society 24:690–705.

WALSH, C. J., A. H. ROY, J. W. FEMINELLA, P. D. COTTINGHAM, P. M. GROFFMAN, AND R. P. MORGAN. 2005b. The urban stream syndrome: current knowledge and the search for a cure. Journal of the North American Benthological Society 24:706–723.

WEAR, D. N., AND D. W. BOLSTAD. 1998. Land-use change in the southern Appalachian landscape: spatial analysis and forecast evaluation. Ecosystems 1:575–594.

WEAR, D. N., AND J. G. GREIS. 2002. Southern forest resource assessment: summary of findings. Journal of Forestry 100:6–14.