Fisheries
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ufsh20

Are We Overlooking Landscape-Scale Threats to Common Freshwater Fishes?

Ryan M. Utz[a]
[a] National Ecological Observatory Network, 1685 38th St., Boulder, CO 80301. E-mail:
Published online: 07 Jul 2014.

To cite this article: Ryan M. Utz (2014) Are We Overlooking Landscape-Scale Threats to Common Freshwater Fishes?, Fisheries, 39:7, 294-297, DOI: 10.1080/03632415.2014.923768

To link to this article: http://dx.doi.org/10.1080/03632415.2014.923768

Are We Overlooking Landscape-Scale Threats to Common Freshwater Fishes?

Ryan M. Utz

National Ecological Observatory Network, 1685 38th St., Boulder, CO 80301. E-mail: rutz@neoninc.org

Assigning a legal conservation status to an imperiled species represents perhaps the most powerful means of halting and reversing the extinction trajectory. Success stories such as the recovery of the bald eagle (*Haliaeetus leucocephalus*) and gray whale (*Eschrichtius robustus*) provide vital evidence of how committed management actions can save endangered species (Noles 2008). Although perhaps less well known, freshwater fishes have also benefited from listing under the Endangered Species Act. For instance, the Big Bend Gambusia (*Gambusia gaigei*) and Humpback Chub (*Gila cypha*) persist in far greater numbers today because their legal status demanded management actions that promoted recovery (Hubbs et al. 2002; Van Haverbeke et al. 2013). States also assign legal conservation status to species under the Endangered Species Act, so many species that are threatened locally but not globally may also receive some degree of legal protection.

What about the fate of fishes that are highly sensitive to land use change but are not considered threatened or endangered?

But does the current roster of state- and federally protected freshwater fishes align with threat of environmental degradation caused by land use change to help preserve all sensitive fish species? The suite of threats contributing to sensitive species decline in aquatic ecosystems consists of many pervasive and nonpoint environmental stressors. Land use change, such as urban and agricultural expansion, has proven to be among the most critical modern-day stressors in aquatic ecosystems because what transpires on land can greatly impact stream ecosystems in fundamental ways. Ecosystem degradation induced by land use change often proves long-term and irreversible (Booth 2005; Howden et al. 2010). Consequently, regions currently undergoing widespread shifts from natural and seminatural spaces to anthropocentric uses stand to permanently lose populations of fishes as streams degrade in environmental quality. All fishes in such streams will likely be affected, and potentially extirpated, as a consequence of land use–driven environmental degradation. The presence of a species with a legal conservation status may influence land use management plans in a watershed slated for development. Yet what about the fate of fishes that are highly sensitive to land use change but are not considered threatened or endangered? How many such species exist?

One component of my dissertation research at the University of Maryland provides data that may address such a question. Using a large spatiotemporal-scale data set of stream ecosystems developed by the Maryland Department of Natural Resources (Klauda et al. 1998), my graduate mentors and I explored species-specific sensitivity of freshwater fishes to anthropocentric land uses for every species of fish collected more than 30 times in the Maryland Biological Stream Survey (Utz et al. 2010). Our work included thresholds that predict the degree of watershed development in which populations would no longer be expected to persist for 54 species. Analyses were partitioned between the Coastal Plain and Piedmont physiographic regions, the border of which divides both major metropolitan regions in Maryland (Baltimore and Washington, D.C.). Table 1 lists the five species that exhibit population loss at the lowest levels of urban cover and their respective extirpation thresholds. Although all relationships between land use and species sensitivity are inherently complex, the thresholds listed in Table 1 may be considered the greatest degree of urban development within a watershed that each species can typically withstand.

To assess the current protection status of species that are highly sensitive to urbanization, I surveyed endangered species checklists from Mid-Atlantic states that encompass the Piedmont and/or Coastal Plain. Of the species we categorized as acutely susceptible to urbanization, alarmingly few are currently considered in need of conservation management action. A majority of fishes we found to be the most sensitive to land use change do not appear on conservation priority rosters (Table 1). Several made "species of concern" lists and the Least Brook Lamprey (*Lampetra aepyptera*) has been designated as threatened in Virginia. None of the nine fishes in Table 1 appear on federal species conservation lists.

Yet considering the degree of urbanization in the Mid-Atlantic (Figure 1), many sensitive fishes may be already absent throughout large portions of their native ranges and at risk of further decline. All Piedmont fishes listed in Table 1 have very likely already been extirpated from a large proportion of their ranges. Urban-sensitive fishes in the Coastal Plain exhibited relatively greater tolerance to urbanization, but many populations throughout large swaths of Maryland, Delaware, and New Jersey, plus those near metropolitan regions further south, are likely dwindling or already extirpated. The small expanse of Coastal Plain within Pennsylvania consists almost entirely of urban land, which likely explains why populations of Pirate Perch (*Aphredoderus sayanus*) no longer exist within that state. Fortunately, urban cover is localized to a significant degree and entirely rural watersheds persist in almost all regions shown in

Table 1 . Thresholds of tolerance to urbanization of the five most urbanization-sensitive fishes identified by Utz et al. (2010) and their conservation statuses. The quantitative threshold represents the point at which 95% of individuals were observed along gradients of watershed urbanization in a Maryland streams database. Gray shaded cells denote natural species absence. C = candidate species, SC = species of concern, SX = presumed extirpated, T = threatened, T2 = tier-2 species of concern.

Province	Fish	Threshold (% urban)	DE	MD	NC	NJ	PA	VA
Piedmont	Rosyface Shiner (*Notropis rubellus*)	7.3						
	Brook Trout (*Salvelinus fontinalis*)	12.1		SC				
	River Chub (*Nocomis micropogon*)	15.2						
	Margined Madtom (*Noturus insignis*)	22.6	T[2]					*a*
	Common Shiner (*Luxilus cornutus*)	20.3						
Coastal Plain	Pirate Perch (*Aphredoderus sayanus*)	12					SX	
	Redfin Pickerel (*Esox americanus*)	16.1						
	Least Brook Lamprey (*Lampetra aepyptera*)	22.7	T[2]		T		C	
	Margined Madtom (*Noturus insignis*)	34.8	T[2]					*a*
	Bluespotted Sunfish (*Enneacanthus gloriosus*)	37		SC				

[a]**The population of Margined Madtoms in the Dan River, Virginia, could merit federal endangered status if determined to be a new species.**

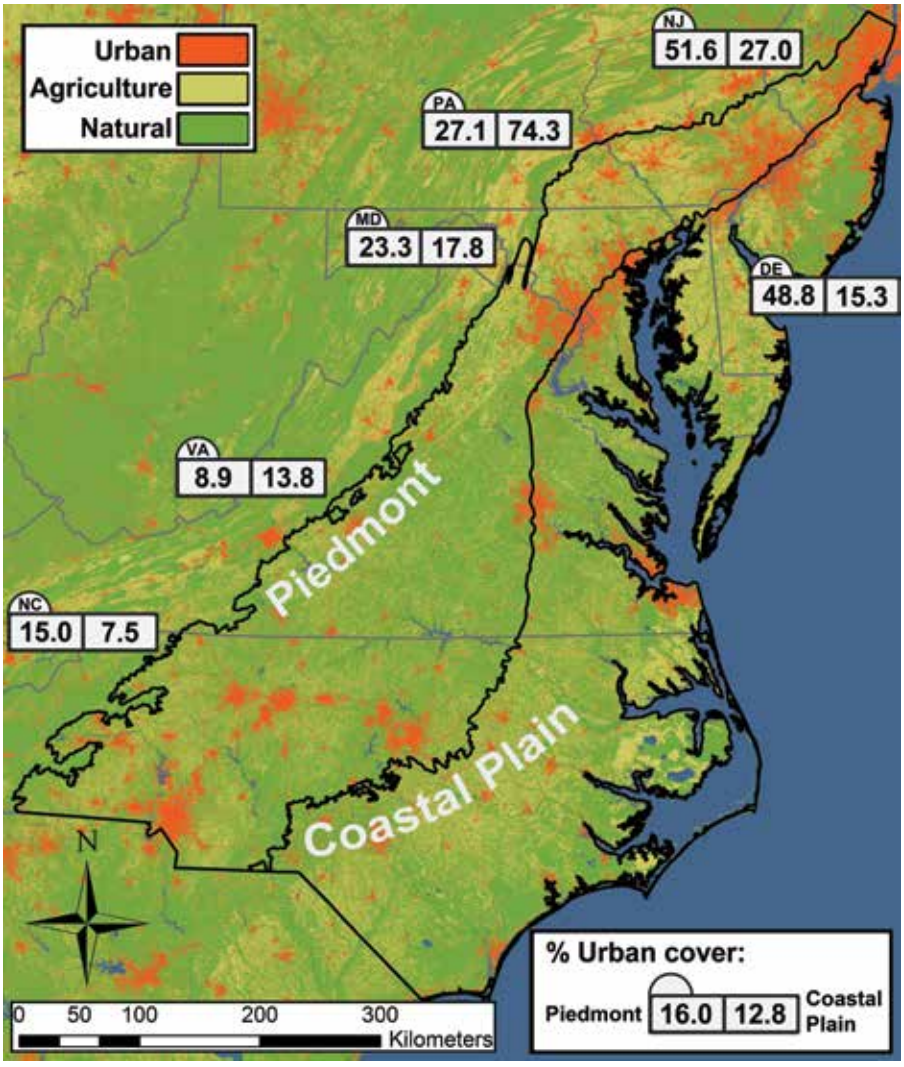

Figure 1. Land use map of the Piedmont and Coastal Plain physiographic regions within the Mid-Atlantic United States. The values in the boxes denote the proportion of land classified as urban in the 2006 National Land Cover Database within the Piedmont (left-hand value within boxes) and Coastal Plain (right-hand value) of each state shown. The total proportion of urban land within each physiographic province of the five-state region is provided in the legend.

Figure 1, thereby offering refuges of high-quality habitat. Some fishes listed in Table 1, such as the Least Brook Lamprey, Margined Madtom (*Noturus insignis*), and Bluespotted Sunfish (*Enneacanthus gloriosus*), are urbanization sensitive but are able to persist in some watersheds with as much as about 35% urban cover. But urban expansion will undoubtedly continue to increase substantially throughout the Mid-Atlantic Piedmont and Coastal Plain (Bierwagen et al. 2010). In light of the current and projected extent of urban development in this region, many fishes with broad distributions could soon require conservation management actions.

In contrast to most taxa assigned legal protection, which tends to be rare and/or endemic to a limited number of drainage basins (Pritt and Frimpong 2010), unlisted sensitive species exhibit broad distributions and are often culturally or ecologically important organisms. For instance, the highly urbanization-sensitive River Chub (*Nocomis micropogon*) constructs well-aerated cobble nests (Peoples et al. 2014) that attract dozens of other fish and invertebrates, resulting in colorful hotspots of ecological activity (Figure 2). Thus, local extirpation of River Chub and other species of *Nocomis* may result in the consequential loss of multiple obligate mutualist species, many of which are rare or threatened (Pendleton et al. 2012). As the only salmonid native to the eastern United States, Brook Trout (*Salvelinus fontinalis*) represent a culturally, economically, and recreationally important species from Georgia to Labrador. Yet only informed anglers from the Mid-Atlantic lowlands realize that native Brook Trout were once found throughout the Piedmont and the few remaining populations in this province persist in watersheds very near to expanding urban sprawl.

The Mid-Atlantic states case study presented herein represents only a small fraction of a trend likely transpiring throughout our rapidly urbanizing world. As the proportion of the global population living in an urban setting is projected to swell from 51.6% to 67.2% between 2010 and 2050 (United Nations 2011), the fraction of watersheds impacted by urbanization will grow accordingly. Lists of potentially overlooked fishes such as those in Table 1 could almost certainly be generated for any expanding metropolitan region, including those in the tropics where a disproportionate proportion of global freshwater fish biodiversity persists near some of the world's fastest growing cities (Grimm et al. 2008). Yet despite recent advancements in urban stream ecology, awareness of common urbanization-sensitive species remains minimal.

So why might traditionally applied conservation management approaches be ill suited to address common, urbanization-sensitive freshwater fishes? Natural resource agencies, which are often confronted with enormous conservation challenges but are rarely provided with adequate resources and/or authority to meet these challenges, justifiably concentrate on species with small populations or limited distributions. Adding common, urbanization-sensitive fishes to the rosters of threatened and endangered species would very likely stretch agency resources to an unsustainable degree and potentially lead to a backlash of public support for species protection programs. The abundance or presence/absence of common sensitive fishes often contributes to Index of Biological Integrity (IBI) scores (Harris 1995), which are successfully applied to help identify impaired ecosystems and should therefore serve as early warning signs of broad-scale population decline for sensitive species. However, unitless IBI scores inherently mask the status of individual populations

Figure 2. A River Chub (*Nocomis micropogon*) tends to his nest while Central Stonerollers (*Campostoma anomalum*) aggregate nearby to take advantage of the structure. Are wonderful scenes such as this endangered in the rapidly urbanizing Mid-Atlantic United States? Photo credit: Jeffrey Basinger / Freshwaters Illustrated.

and the presence of environmentally sensitive nonnative fishes may result in higher IBI scores (Hermoso and Clavero 2013). Given the acute sensitivity of many fishes to urbanization and multivariate nature of IBI systems, a moderately impacted stream could retain a high IBI score and thus fail to signal an alarm bell for one or more particularly sensitive native species.

Consequently, effectively monitoring and conserving populations of common but sensitive fishes may require a mix of traditional and novel approaches. Effective mitigation and preventative measures to reduce the holistic impact of urbanization on streams, such as disconnecting hydrologic pathways between impervious surfaces and natural channels (Jackson and Pringle 2010; Wenger et al. 2010), are becoming mainstream and will likely prove beneficial for all lotic fishes where implemented. Other investigators have highlighted the potential of natural riparian wetlands to significantly moderate the effect of urban development in streams (Harrison et al. 2011). Beyond IBI scores and attention to globally imperiled taxa, a revised professional perspective on individual species may be warranted. Data already routinely collected to calculate IBI scores might also be used to also closely monitor at-risk species such as those listed in Table 1 by focusing attention on individual species in addition to assemblage-scale metrics. Patterns drawn from such data that suggest that populations or distributions are on a clear negative trajectory could help warrant management actions that prevent endangered species rosters from growing. Past experience shows that the mere threat of federal listing under the Endangered Species Act can prompt local management actions that effectively sustain at-risk populations (Federal Register Office 2010). The ubiquity of fishes listed in Table 1 also represents a scientific opportunity: ecosystems where these sensitive species persist despite the presence of urban sprawl could be carefully examined to identify watershed attributes that successfully help retain biodiversity.

Ultimately, I cannot suggest a management solution that I feel will adequately protect all fishes threatened by land use change. My goal here is to highlight the breadth of ichthyofauna we risk losing under our watch if we limit conservation resources to protecting rare species and identify impaired waters only through multivariate indices. If Utz et al. (2010) causes agency personnel to more carefully consider common species that may be on the decline, I would consider my work a success. In my view, preventing losses of backyard biodiversity is a crucial component of biological conservation, even when rare species are not at stake.

ACKNOWLEDGMENTS

The author thanks Jeffrey Basinger and Freshwaters Illustrated for the excellent image of a River Chub and Bob Hilderbrand, Dave Kazyak, and two anonymous reviewers for providing helpful comments on an earlier draft of this perspective.

FUNDING

The author is supported by National Science Foundation cooperative agreement #EF1138160, awarded to fund the National Ecological Observatory Network (NEON).

REFERENCES

Bierwagen, B. G., D. M. Theobald, C. R. Pyke, A. Choate, P. Groth, J. V. Thomas, and P. Morefield. 2010. National housing and impervious surface scenarios for integrated climate impact assessments. Proceedings of the National Academy of Sciences 107:20887–20892.

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.

Federal Register Office. 2010. Endangered and threatened wildlife and plants; 12-month finding on a petition to list the Amargosa toad as threatened or endangered. Federal Register 75:138(20 July 2010):42040–42054.

Grimm, N. B., S. H. Faeth, N. E. Golubiewski, C. L. Redman, J. Wu, X. Bai, and J. M. Briggs. 2008. Global change and the ecology of cities. Science 319:756–760.

Harris, J. H. 1995. The use of fish in ecological assessments. Australian Journal of Ecology 20:65–80.

Harrison, M. D., P. M. Groffman, P. M. Mayer, S. S. Kaushal, and T. A. Newcomer. 2011. Denitrification in alluvial wetlands in an urban landscape. Journal of Environment Quality 40:634–646.

Hermoso, V., and M. Clavero. 2013. Revisiting ecological integrity 30 years later: non-native species and the misdiagnosis of freshwater ecosystem health: ecological integrity in freshwaters. Fish and Fisheries 14:416–423.

Howden, N. J. K., T. P. Burt, F. Worrall, M. J. Whelan, and M. Bieroza. 2010. Nitrate concentrations and fluxes in the River Thames over 140 years (1868–2008): are increases irreversible? Hydrological Processes 24:2657–2662.

Hubbs, C., R. J. Edwards, and G. P. Garrett. 2002. Threatened fishes of the world: *Gambusia gaigei* Hubbs, 1929 (Poeciliidae). Environmental Biology of Fishes 65:82–82.

Jackson, C. R., and C. M. Pringle. 2010. Ecological benefits of reduced hydrologic connectivity in intensively developed landscapes. BioScience 60:37–46.

Klauda, R., P. Kazyak, S. Stranko, M. Southerland, N. Roth, and J. Chaillou. 1998. Maryland biological stream survey: a state agency program to assess the impact of anthropogenic stresses on stream habitat quality and biota. Environmental Monitoring and Assessment 51:299–316.

Noles, J. L. J. 2008. Is recovered really recovered: recovered species under the Endangered Species Act. Cumberland Law Review 39:387–436.

Pendleton, R. M., J. J. Pritt, B. K. Peoples, and E. A. Frimpong. 2012. The strength of *Nocomis* nest association contributes to patterns of rarity and commonness among New River, Virginia Cyprinids. The American Midlands Naturalist 168:202–217.

Peoples, B. K., R. A. McManamay, D. J. Orth, and E. A. Frimpong. 2014. Nesting habitat use by River Chubs in a hydrologically variable Appalachian tailwater. Ecology of Freshwater Fish 23:283–293.

Pritt, J. J., and E. A. Frimpong. 2010. Quantitative determination of rarity of freshwater fishes and implications for imperiled-species designations. Conservation Biology 24:1249–1258.

United Nations. 2011. World urbanization prospects, the 2011 revision. Department of Economic and Social Affairs, Population Division of the United Nations. Available: http://esa.un.org/unup/. (May 2013).

Utz, R. M., R. H. Hilderbrand, and R. L. Raesley. 2010. Regional differences in patterns of fish species loss with changing land use. Biological Conservation 143:688–699.

Van Haverbeke, D. R., D. M. Stone, L. G. Coggins, and M. J. Pillow. 2013. Long-term monitoring of an endangered desert fish and factors influencing population dynamics. Journal of Fish and Wildlife Management 4:163–177.

Wenger, S. J., M. C. Freeman, L. A. Fowler, B. J. Freeman, and J. T. Peterson. 2010. Conservation planning for imperiled aquatic species in an urbanizing environment. Landscape and Urban Planning 97:11–21.

RELATED AFS POLICY:

AFS Policies #5 on "Cumulative Effects of Small Modifications to Habitat," #9 on "Effects of Altered Steam Flows on Fishery Resources," #13 on "Effects of Surface Mining on Aquatic Resources," #14 on "Strategies for Stream Riparian Area Management," and #23 on "Effects of Grazing on Riparian Stream Ecosystems."