Distribution and Environmental Drivers of Slimy and Mottled Sculpin Populations in the Turkey River Drainage of Iowa's Driftless Area

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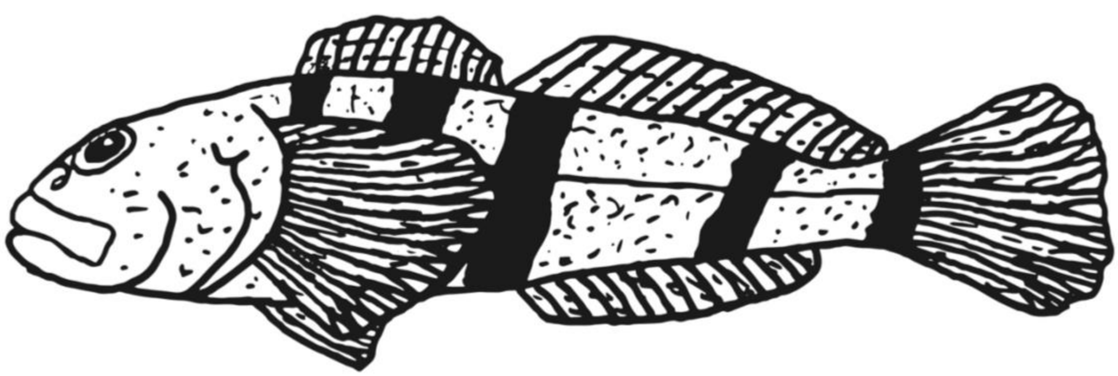

Objectives

The objective of the proposed study is to perform backpack electrofishing surveys in wadable streams throughout the Turkey River drainage in northeast Iowa to document the status and environmental drivers of two non-game fishes – the Slimy (*Cottus cognatus*) and Mottled (*Cottus bairdii*) Sculpins. These surveys will evaluate the potential effects of *in-situ* habitat and water quality variables, as well as the presence of larger fish predators (i.e., Brook Trout, *Salvelinus fontinalis*; Brown Trout, *Salmo trutta*). Landscape and land-use-land-cover (LULC) variables will also be used to link broad-scale variables to Sculpin populations.

Project Area

This study will take place within the boundaries of the Turkey River drainage, which is a 153-mile (246 km) tributary of the upper Mississippi River (UMR) and covers nearly 4,300 km^2 in Iowa's Driftless region (Figure 1). The Turkey River begins in Howard County and flows southeast through six additional counties – Chickasaw, Winneshiek, Fayette, Clayton, Delaware, and Dubuque – before merging with the UMR near Guttenberg, Iowa. The Turkey River drainage has been identified as an Iowa priority watershed with high recovery potential for nutrient and sediment loading by the United States Environmental Protection Agency's Recovery Potential Screening (USEPA, 2016).

Procedures

Site selection: The location and number of potential sample sites within the Turkey River drainage will be determined based on site accessibility, land-owner relations and permissions, and previous Iowa Department of Natural Resources' (IDNR) biomonitoring efforts (i.e., BioNet). Representative sample sites will be selected from each 12-digit Hydrologic Unit Code (HUC12) using the Iowa stream centerlines layer acquired from Iowa Geospatial Data (2020) to achieve a spatially-balanced random sampling design.

Fish sampling: Sample locations will consist of three spatially replicated reaches with length of sample reach depending on stream width (targeting length 40 times mean wetted width; Angermeier and Smogor 1995; Dauwalter and Pert 2003; Reynolds et al. 2003). All three reaches will be located along the same stream segment and separated by one pool–riffle–run sequence, natural barriers (e.g., riffles, cascades), or both to minimize immigration and emigration from the reach during sampling. At each sample location, we will collected fish using three-pass backpack electrofishing (Smith-Root LR-24, Vancouver, WA, USA) with two dip netters between June and August. Where necessary, we will also use block nets and natural barriers to ensure closed populations during sampling. All fish will be identified to species, measured for standard length, weighed (nearest 0.01 gram), and released back to the original site of capture.

In-stream variables: At each sample site, we will measure several *in-situ* water quality and habitat variables known to affect sensitive fishes to evaluate their potential influence on Sculpin populations. Specifically, we will measure *in-situ* water temperature (°C), pH, dissolved oxygen (mg L^{-1}), and specific conductivity ($\mu S_{25^{\circ}C}\ cm^{-1}$) using a hand-held water quality meter. All water quality measurements will be taken prior to fish sampling to reduce the effects of sampling on water quality. We will deploy HOBO temperature loggers (Onset Computer Corporation, Bourne, Massachusetts, USA) at sites in May and June 2023, retrieving them at the end of summer to provide continuous temperature profiles that will also aid the IDNR's stream reclassification efforts. We will measure in-stream habitat at each site using the cross-sectional transect method (Barbour et al. 1999). We will focus on metrics associated with habitat size (i.e., width, depth) and substrate type (i.e., fine sediments, sand, gravel, cobbles, boulder, bedrock, large wood), providing information relevant to fish feeding and spawning habitats. We will identify additional aspects of habitat quality, such as cover availability (i.e., large wood, undercut banks) and bank stability. At each transect — established every 10 m — habitat measurements will be recorded at five points (i.e., 5%, 25%, 50%, 75% and 95%) along the wetted channel width. If fine sediments are present, sediment depth will be measured at each point by inserting a meter stick into soft sediments until a coarser substrate underneath is reached. Discharge is a key regulator of fish populations in lotic ecosystems (Poff et al., 1997); therefore, we will also estimate discharge at each site using the cross-sectional method with a Marsh McBirney Flo-Mate™ velocity meter (Model 2000; Buchanan & Somers, 1969).

Landscape variables: Landscape (i.e., latitude, longitude, elevation, catchment area, soils, lithology) and LULC (i.e., forest, urban, agriculture) data will be derived from the National Land Cover Database (NLCD; http://www.mrlc.gov/data) and the USEPA's StreamCat dataset (Hill et. al., 2016). For each site, we will use Geographic Information System to record the associated landscape information. For each upstream catchment, we will calculate the percentage of the catchment occupied by agriculture, urban development, and forest cover. Agricultural land cover will encompass NLCD classes cropland, including orchards and vineyards (82), and pasture (81). Developed LULC will include NLCD classes for open urban land (21), low-density residential (22), medium-density residential (23), high-density residential, commercial, industrial, and institutional land (24). Forest LULC will aggregate NLCD classes deciduous (41), evergreen (42), mixed forest cover (43).

Problem & Need

Stream ecosystems are inherently complex networks of entangled, interacting relationships among different environmental and biotic variables (Jackson *et al.*, 2016). By disentangling these ecological networks, stakeholders and managers can implement targeted conservation, best management, and restoration practices geared towards protecting and enhancing the biological condition of streams (Craig *et al.*, 2017). This requires a comprehensive understanding of the factors regulating populations and communities at different spatial and temporal scales (Abbott *et al.*, 2018). Numerous landscape, climate, and in-stream predictors have been identified as important drivers for stream fish populations (Patrick *et al*., 2019, Schmidt *et al*., 2019). Due to the intimate link between the landscape and downstream aquatic habitats (Hynes, 1975), changes in anthropogenic land use can alter many in-stream predictors and increase the complexity of these ecological networks, further challenging conservation and management actions (Allan 2004; Vorosmarty *et al.*, 2010; Best, 2019). For example, stream catchments simultaneously exposed to urban development and agricultural land use commonly show augmented levels of ions, nutrients, sediments, and temperatures, but identification of the specific landscape-ecology relationships is compounded by these multiple anthropogenic threats on the landscape (Craig *et al.*, 2017). Therefore, detailed monitoring and survey efforts to further identify the underlying drivers and linkages between landscape, climate, in-stream predictors, and biological processes for many streams fishes are still needed.

The Turkey River drainage in northeast Iowa is of particular interest, as it has been identified as a priority watershed with high recovery potential (USEPA, 2016). Based on EPA's 2016 report, the Turkey River is characterized as having excess sediments, nitrogen, phosphorous, and altered temperatures associated with agricultural runoff, potentially having deleterious effects on sensitive aquatic species. In addition, IDNR personnel have indicated that our understanding of fish distributions throughout in the Turkey River drainage, especially for non-game species, is very limited, warranting further evaluations to help identify if environmental degradation continues or if implemented restoration efforts stimulate population recovery. In particular, Sculpin are benthic fishes, usually found in clear, rocky-bottom streams. They are highly sensitive to alterations in water and habitat quality because they rely on these coarse substrates for spawning and finding food. And with augmented sediments and other stressors associated with increased anthropogenic activities, the filling of interstitial spaces and loss of coarse substrates are likely to negatively affect Sculpin populations. However, since much of the land in Iowa's Driftless region is privately owned (IDNR 2015), information on the distribution and population ecology of Sculpin in headwater systems throughout the region is largely unavailable, making the proposed study timely.

This proposed study will ultimately aid the IDNR in: 1) better understanding Slimy (*Cottus cognatus*) and Mottled (*Cottus bairdii*) Sculpin distributions and ecology, 2) identifying the most important local- and catchment-scale predictors regulating Sculpin populations, and 3) cold-water stream reclassification efforts throughout the Driftless region.

Personnel & Tasks

Richard H. Walker, Principal Investigator (see resume below), Upper Iowa University. Conduct electrofishing surveys, data entry, data analysis, report writing, presentation of results.

Yet-to-be-determined-undergraduate student, Seasonal Field Assistant. Conduct electrofishing surveys, data entry, data analysis, presentation of results, and article writing for senior thesis.

Proposed Budget

Item	Amount ($)
2 Field Assistant ($60/day x 30 work days)	3600
Mileage	400
Field supplies (dip nets, waders, batteries, notebooks)	1000
Total	**5000**

Additional funding is being sought from the Iowa Trout Unlimited, Iowa Academy of Science, Iowa Department of Natural Resources, and Upper Iowa University.

Calendar

1 April to 1 June, 2022: Determination of sample location

1 June to 1 August, 2022: Conduct survey and data entry

1 August, 2022 to 31 March, 2023: Data entry, report writing

31 March, 2023: Submission of final report

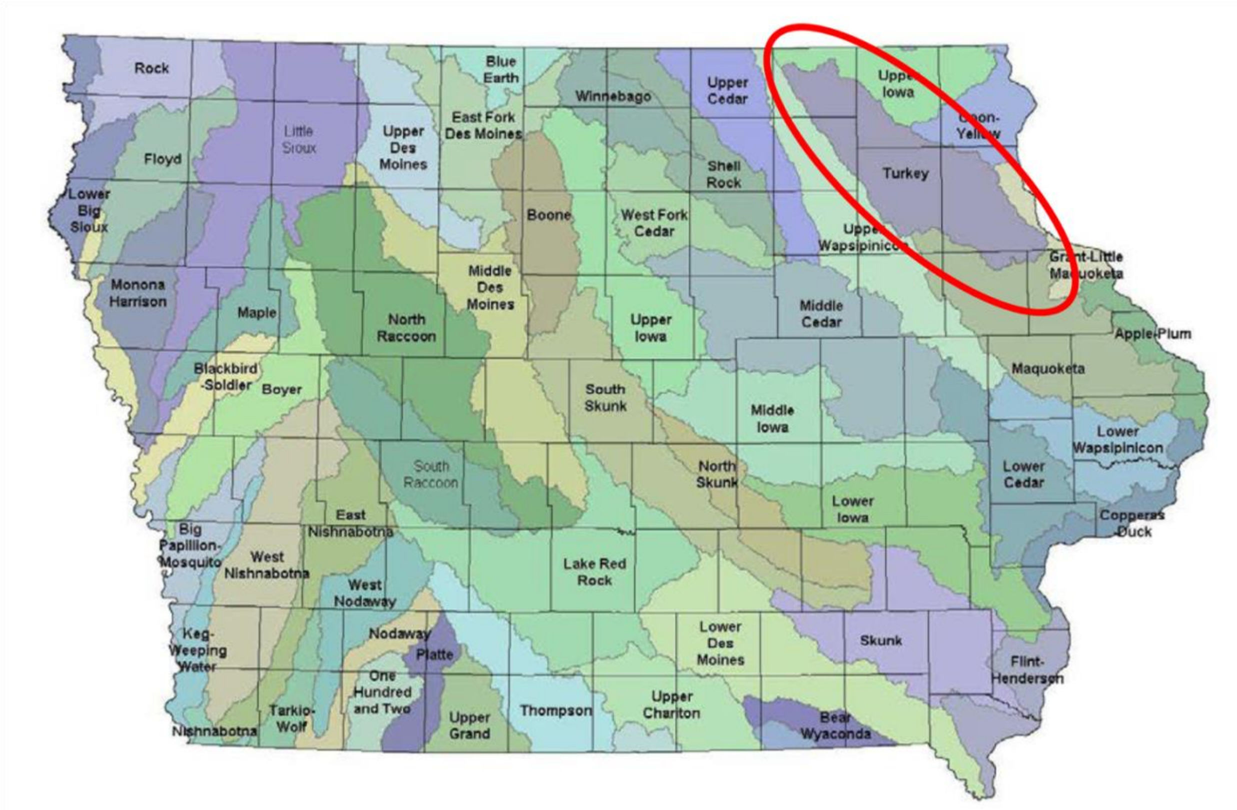

Figure 1. Map of HUC8 watersheds of Iowa. Study area includes wadable streams within the boundaries of Turkey River drainage in northeast Iowa. Map adapted from USEPA Recovery Potential Screening Report (USEPA, 2016).

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Richard H. Walker

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Education

May 2019 — **Ph.D., Ecology**, University of Wyoming, Laramie, Wyoming. Supervisor: Annika Walters. *Dissertation title*: Ecological responses to multiple stressors in headwater streams.

May 2011 — **M.S., Biology**, University of Central Arkansas, Conway, Arkansas. Supervisor: Ginny and Reid Adams. *Thesis title*: Movement Patterns of Southern Redbelly Dace, *Chrosomus erythrogaster*, in a Headwater Reach of an Ozark Stream.

May 2008 — **B.S., Environmental Science**, University of Central Arkansas, Conway, Arkansas. Supervisor: Ginny and Reid Adams. *Thesis title*: Differences in diet and feeding ecology of similar-sized spotted (*Lepisosteus oculatus*) and shortnose (*Lepisosteus platostomus*) gars foraging during flooding of a southeastern USA river.

Professional employment

2022 – present — **Assistant Professor of Fisheries**, Dept. of Biology & Chemistry, Upper Iowa University, Fayette, IA.

2020 – 2022 — **Postdoctoral Research Fellow**, U.S. Geological Society, Eastern Ecological Science Center @ Leetown Laboratory, Kearneysville, WV.

2020 — **Postdoctoral Researcher**, Dept. of Entomology, Virginia Tech, Blacksburg, Virginia

2019 – 2020 — **Adjunct Professor**, Dept. of Biology, American University, Washington, D.C.

2014 – 2019 — **Graduate Research Assistant**, Dept. of Zoology and Physiology, University of WY, Laramie, WY.

2013 – 2014 — **Research Assistant**, BLM's National Aquatic Monitoring Center, Utah State University, Logan, UT

2012 – 2013 — **Research Assistant**, Fish Ecology Lab, Dept. of Watershed Sciences, Utah State University, Logan, UT.

2012 — **Research Assistant**, Trout Unlimited, Boise, ID.

2010 – 2012 — **Environmental Scientist**, GBMc & Associates, Bryant, AR.

2008 – 2010 — **Graduate Research Assistant**, Dept. of Biology, University of Central Arkansas, Conway, AR.

2008 — **Research Assistant,** Utah Division of Natural Resources, St. George, UT

2005 – 2008 — **Undergraduate Research Assistant**, Dept. of Biology, University of Central Arkansas, Conway, AR.

Peer-reviewed publications

1. **Walker, R.H.,** Ashton, M. J., Cashman, M. J., Fanelli, R.M., Krause, K.P., Noe, G.B., & Kelly O. Maloney, K.O. 2021. Time marches on, but do the causal pathways driving instream habitat and biology remain consistent? *Science of the Total Environment.* https://doi.org/10.1016/j.scitotenv.2021.147985
2. Bates, M.L., **Walker, R.H.,** Alfred, A., and Entrekin, S.A. 2021. Intermittency mediates macroinvertebrate and crayfish effects on leaf decomposition in streams. *Freshwater Science*. 40: 21-38. https://doi.org/10.1086/713094
3. **Walker, R.H.**, Smith, G.D., Hudson, S.B., French, S.S., and Walters, A.W. 2020. Warmer temperatures interact with salinity to weaken physiological facilitation to stress in stream fishes. *Conservation Physiology.* coaa107. https://doi.org/10.1093/conphys/coaa107
4. **Walker, R.H**., Orr, M.C., and Miller, S.W. 2020. Factors contributing to leaf decomposition vary with temperature in two montane rivers of the Intermountain West, Utah. *Aquatic Sciences*. 82: 49. https://doi.org/10.1007/s00027-020-00723-1
5. **Walker, R.H.,** Girard, C.E., Alford, S.L., and Walters, A.W. 2019. Anthropogenic land-use change intensifies the effect of low flows on stream fishes. *Journal of Applied Ecology*. 57: 149-159. https://doi.org/10.1111/1365-2664.13517
6. **Walker, R.H.** and Walters, A.W. 2019. A mechanistic understanding of ecological response to land-use change in headwater streams. *Ecosphere*. 10: e02907. https://doi.org/10.1002/ecs2.2907
7. Walters, A.W., Girard, C.E., **Walker, R.H.**, Farag, A.M., and Alvarez, D.A. 2019. Multiple approaches to surface water quality assessment provide insight for small streams experiencing oil and natural gas development. *Integrative Environmental Assessment and Management*. 15: 385-397. https://setac.onlinelibrary.wiley.com/doi/abs/10.1002/ieam.4118
8. **Walker, R.H**., Maitland, B.M., Rosing, M.N., Ben-David, M. 2018. Fate of juvenile salmonids stranded in off-channel flood ponds. *Aquatic Sciences*. 80: 10. https://doi.org/10.1007/s00027-017-0562-z

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13. **Walker, R.H.**, Kluender, E., Inebnit, T.E., & Adams, S.R. 2013. Differences in diet and feeding ecology of similar-sized spotted (*Lepisosteus oculatus*) and shortnose (*Lepisosteus platostomus*) gars foraging during flooding of a southeastern USA river. *Ecology of Freshwater Fish*. 22: 617-625. **https://doi.org/10.1111/eff.12066**

Selected oral presentations (*Best paper)

- Spring 2021. Ecological responses to multiple stressors in aquatic ecosystems. Department of Forestry and Environmental Conservation, Clemson University.
- Fall 2020. Multiple stressors in aquatic ecosystems. Department of Biology, Emporia State University
- Spring 2020. Warmer temperatures interact with salinity to weaken physiological facilitation to stress in stream fishes. Salinization Working Group, Virginia Tech.
- Spring 2020. Going with the Flow: Fish Ecology in a Changing World. American Fisheries Society, Virginia Tech
- Fall 2019. Ecological responses to multiple stressors in headwater streams. Environment and Civil Engineering, Latvia University of Life Sciences and Technologies.
- Spring 2019. **Richard H. Walker**, Carlin Girard, Samantha Alford, and Annika Walters. Surface disturbance intensifies the effect of low flows on stream fishes. Society for Freshwater Science, Salt Lake City, UT.
- Fall 2018. **Richard H. Walker** and Annika W. Walters. Mechanisms Underlying Ecological Responses to Surface Disturbance in Headwater Streams. Joint Wyoming Wildlife Society and WLCI Annual Conference. Laramie, WY.
- ***Spring 2016. **Richard H. Walker**, Carlin Girard, and Annika Walters. Does oil and natural development interact with hydrology to affect fish populations? Program in Ecology Student Symposium, University of Wyoming. Laramie, WY
- ***Spring 2016. **Richard H. Walker**, Carlin Girard, and Annika Walters. Does oil and natural development interact with hydrology to affect fish populations? CO/WY American Fisheries Society Annual Conference. Laramie, WY
- Fall 2015. **Richard H. Walker**, Carlin Girard, and Annika Walters. Does oil and natural development interact with hydrology to affect fish populations? Joint Wyoming Wildlife Society and Wyoming Landscape Conservation Initiative Annual Conference. Lander, WY.
- Fall 2013. **Richard H. Walker** and Ginny Adams. Ecological factors influencing movement of creek chub in an intermittent stream of the Ozark Mountains, Arkansas. National AFS, Little Rock, AR
- ***Spring 2011. **Richard H. Walker**, Ginny Adams, and Reid Adams. Movement Patterns of Southern Redbelly Dace, *Chrosomus erythrogaster*, in a Headwater Reach of an Ozark Stream. Arkansas AFS, Little Rock, AR.

Selected poster presentations (*Best paper)

- ***Spring 2009. **Richard H. Walker**, Michael Orr, and Scott Miller. Mechanisms of Leaf Decomposition in Two Streams of the Intermountain West: Examining the Functional role of an Extirpated Shredding Invertebrate. University of Wyoming's Program in Ecology's Student Symposium. Laramie, Wyoming.
- Fall 2009. **Richard H. Walker**, Ginny Adams, and Reid Adams. Environmental Influences on Movement Patterns Two Cyprinids in an Intermittent Reach of an Ozark Stream. Southeastern Fishes Council.
- Spring 2008. **Richard H. Walker**, Justin Benton, and Tommy Inebnit. Food Habits of Sympatric Spotted (*Lepisosteus oculatus*) and Shortnose (*Lepisosteus platostomus*) Gar during Flooding of an Arkansas River Tributary. Advisor: Dr. Reid Adams. University of Central Arkansas Research Symposium.
- Spring 2008. Tommy Inebnit, Luke Driver, **Richard H. Walker,** and Reid Adams. Fishy Explorations on the Fourche LaFave River: Who were the Beneficiaries of an Extensive Summer Flood. Advisor: Dr. Reid Adams. University of Central Arkansas Research Symposium.