NH Water Resources Research Center
University of New Hampshire

Annual Technical Report
2019

Products

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Antonellis, C. Microbial Communities Associated with Pharmaceutical and Personal Care Products in New Hampshire Wastewater Treatment Facilities. UNH MS Thesis in preparation.

Fazekas, H. M., Wymore, A. S., & McDowell, W. H. 2020. Dissolved organic carbon and nitrate concentration-discharge behavior across scales: Land use, excursions, and misclassification. Water Resources Research, 56, e2019WR027028. https://doi.org/10.1029/2019WR027028

Herreid, A.M. 2019. Divergent controls on stream greenhouse gas concentrations across a land use gradient. M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, New Hampshire, 43 pages.

Herreid, A.M., Wymore, A.S., Varner, R.K. et al. 2020. Divergent Controls on Stream Greenhouse Gas Concentrations Across a Land-Use Gradient. Ecosystems. https://doi.org/10.1007/s10021-020-00584-7.

Hidrovo A, Luek JL, Antonellis, C., Malley JP, and Mouser PJ. In Review. The Fate and Removal of Pharmaceuticals and Personal Care Products Within Wastewater Treatment Facilities Discharging into New Hampshire's Great Bay Estuary. *Environmental Sciences: Water Research & Technology*.

Nelson, S.J., C.Y. Chen, J.S. Kahl, 2019. Dragonfly larvae as biosentinels of Hg bioaccumulation in Northeastern and Adirondack lakes: relationships to abiotic factors. Ecotoxicology, 29: 1659–1672. DOI: 10.1007/s10646-019-02149-4

Nguyen, B, B. O'Donnell, A. Villamagna. Accepted 2021. Integrative stress in wild Brook Trout detected with inducible HSP70. Conservation Physiology.

Patel K.F., Tatariw C., MacRae J.D., Ohno T., Nelson S.J. & Fernandez I.J. 2020. Snowmelt periods as hot moments for soil N dynamics: A case study in Maine, USA. Environmental Monitoring and Assessment, 192, 777. https://doi.org/10.1007/s10661-020-08733-0. Available: https://rdcu.be/ca8nd

Patel, K., Fernandez, I.J., Nelson, S.J., Gruselle, M.-C., Norton, S.A., and Weiskittel, A.R. 2019. Forest N dynamics after 25 years of whole watershed N enrichment: The Bear Brook Watershed in Maine. Soil Science Society of America Journal 83(1): S161-S174.

Patel, K.F., I.J. Fernandez, S.J. Nelson, C.J. Spencer, and S.A. Norton. 2020. The Bear Brook Watershed in Maine, USA: Long-term atmospheric deposition chemistry 1987 - 2012 ver 1. Environmental Data Initiative. https://doi.org/10.6073/pasta/c207d374793da5168749d460a4933f2f.

Patel, K.F., I.J. Fernandez, S.J. Nelson, C.J. Spencer, and S.A. Norton. 2020. The Bear Brook Watershed in Maine, USA: Soil quantitative pit chemistry 1998 - 2010 ver 1. Environmental Data Initiative. https://doi.org/10.6073/pasta/d100ba93b45049ed7bc7d81ef9aa9304.

Patel, K.F., I.J. Fernandez, S.J. Nelson, C.J. Spencer, and S.A. Norton. 2020. The Bear Brook Watershed in Maine, USA: Soil moisture record 2003 - 2016 ver 1. Environmental Data Initiative. https://doi.org/10.6073/pasta/5d2772e51968230ceec2242e8990529e.

Patel, K.F., I.J. Fernandez, S.J. Nelson, J. Malcomb, S.A. Norton. 2020. Contrasting stream nitrate and sulfate response to recovery from experimental watershed acidification. Biogeochemistry Letters. https://doi.org/10.1007/s10533-020-00711-5.

Pérez Rivera, K. 2020. Limited uptake of labile C in forested headwater streams. M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, New Hampshire.

Rodriguez-Cardona, B. 2020. Carbon and Nitrogen Dynamics in Fluvial Systems across Biomes. PhD Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, New Hampshire.

Saccardi, B. 2019. Disappearing temporal patterns: The spatial variability of CO_2 in headwater streams. M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, New Hampshire, 26 pages.

Shanley, J.B., Taylor, V.T., Ryan, K.A., Chalmers, A.T., Perdrial, J. and Stubbins, A. Accepted-02-15-21. The role of DOM quality in total mercury and methylmercury dynamics in a forested headwater stream. Hydrological Processes.

Shanley, J.B., Ryan, K.A., Taylor, V.T., Chalmers, A.T., Perdrial, J. and Stubbins, A. 2021. Mercury, methylmercury, cations, dissolved organic carbon and dissolved organic matter optical properties in small, forested streams during five synoptic sampling campaigns at Sleepers River, Vermont, 2017-2018. Science Direct. https://doi.org/10.5066/P9380HQG

Press Releases:

Faculty members from UNH named as fellows by science organizations. Union Leader. November 30, 2020. https://www.unionleader.com/news/education/faculty-members-from-unh-named-as-fellows-by-science-organizations/article_29292362-3be9-5657-a967-ec3cf661fb6b.html

Living Laboratory: Graduate student awarded fellowship at Great Bay. UNH Today July 31,2020. https://www.unh.edu/unhtoday/2020/07/living-laboratory. Written by Lily Greenberg.

New Hampshire's Trusted Partner. UNH research contributes to the well-being of the state's citizenry. NH WRRC as strong supporter of clean water and healthy ecosystems in the state. https://www.unh.edu/unhtoday/2020/04/new-hampshires-trusted-partner

New UNH master's student Anna Lowien received a Margaret A. Davidson Graduate Fellowship to work at the Great Bay National Estuarine Reserve. Details are described in the following press release:

Living Laboratory: Graduate student awarded fellowship at Great Bay. UNH Today July 31,2020. https://www.unh.edu/unhtoday/2020/07/living-laboratory. Written by Lily Greenberg.

Station scientists receive honors for Earth science research. Morning AgClips. December 3, 2020. https://www.morningagclips.com/station-scientists-receive-honors-for-earth-science-research/

Station Scientists Receive Prestigious Honors for Earth Science Research. New Hampshire Agricultural Experiment Station. November 30, 2020. https://colsa.unh.edu/nhaes/article/2020/12/honors. Written by Lori Tyler Gula.

UNH professors receive prestigious honors. Foster's Daily Democrat. November 29, 2020. https://www.fosters.com/story/news/education/2020/11/27/unh-professors-receive-prestigious-honors/6413355002/

Information Transfer Program

As part of the information transfer program, the Center's Director and Associate Director meet with state representatives, local town officials, watershed groups, scientists and the general public to discuss NH WRRC findings regarding the impacts of population growth on potable water supply and ecosystem health in New Hampshire and the region. The NH WRRC website (http://www.wrrc.unh.edu/) is used to disseminate information on water resources and is maintained with funding provided by this project.

The NH WRRC Associate Director also participates on the planning committee of the **NH Water and Watershed Conference** (NHWWC) and organizes the **Annual Lamprey River Symposium**. The annual NHWWC is designed to meet the information and networking needs of watershed groups, environmental organizations, volunteers, municipal board and staff members, consultants, elected officials, planners, policy makers, scientists, educators, and students. The state conference typically draws over 250 people. The goal of the Annual Lamprey River Symposium is to facilitate discussion and collaboration among scientists working in the Lamprey River basin and to engage local, state and federal officials, watershed organizations, and concerned citizens with the science and its implications for Great Bay and the entire coastal watershed. The symposium attracts approximately 90 attendees. The Lamprey River is the largest tributary to Great Bay and the recent impairment of Great Bay for elevated nitrogen has prompted significant focus on reducing nitrogen loading to the bay. Both the Director and Associate Director have participated in numerous discussions around this topic.

Student Support

	# of Students
Undergraduate students	20
Graduate students	12
Post-docs	3

Notable Achievements and Awards

- UNH and the NH Water Resources Research Center were recognized as the state's trusted partner for research that contributes to the well-being of the state's citizenry (see press release).
- Data and results from various NH WRRC projects are shared with local river and lake watershed groups and the general public.
- The NH WRRC has produced 18 scientific publications and participated in 7 press releases during this reporting period.
- NH WRRC students, staff and investigators have given 27 presentations at regional, national, and international scientific meetings and 7 presentations at public meetings during this reporting period.
- NH WRRC director Dr. McDowell was named a 2020 fellow of the American Geophysical Union (AGU) based on his contribution to advancing the field of geoscience through his research that focuses on understanding the role of small streams in global carbon and nitrogen cycles (see press releases).
- Dr. Amy Villamagna (PI of 2019NH175B) was honored as the Distinguished Scholar of the Year at Plymouth State University 2020-21. She was also honored with the Helen Abbott Endowed Professors of Environmental Studies (2016-2019) for her research on the environment and engagement of students in research.
- Findings from the 2016NH205G project were the basis for an NSF EPSCoR Track IV award studying sources of mercury in the watershed using isotopic signatures, and an internal institutional CompX computer science grant to analyze organic carbon and landscape data.
- NH WRRC Graduate student Anna Lowien was awarded a 2020 Margaret A. Davidson Graduate Fellowship at the Great Bay National Estuarine Reserve (see press releases).
- Graduate student Stephanie Dykema received the best student presentation award at the 2019 NADP Scientific Symposium and Fall Meeting.
- Amanda Gavin, a former NH WRRC graduate student, received a National Science Foundation Research Traineeship (NSF -NRT) award and will be pursuing a PhD at the University of Maine Fall 2021.
- An undergraduate student supported by the 2019NH174B project is pursuing a graduate degree in Tennessee. A post-doc supported by this same project has obtained a position at the Portsmouth Naval Shipyard.
- Numerous NH WRRC students and staff are females in STEM.

Water Quality and The Landscape: Long-term Monitoring of Rapidly Developing Suburban Watersheds

Project Type: Annual Base Grant
Project ID: 2019NH173B

PROJECT IMPACT:

This project documents long-term changes to water quality in three of New Hampshire's rapidly developing watersheds: the Ossipee River watershed in central NH and the Lamprey and Oyster River watersheds located in southeast NH. Samples are collected by staff, students and volunteers and analyzed in the NH Water Quality Analysis Laboratory by staff and students.

In the Lamprey and Oyster River watersheds where we have approximately 20 years of data, we have begun to document changes in water quality. We have documented a statistically significant long-term increase in mean annual nitrate in the Lamprey River. In both the Lamprey and Oyster River watersheds, we have documented a dramatic increase in Na^+ and Cl^- over a longer time period in response to increased road salt application in these watersheds (Daley et al. 2009 and recent data). Continued long-term monitoring of these sites is necessary to determine if the direction and magnitude of these documented changes will continue with ongoing changes in land use, watershed management practices and climate variability.

The Lamprey River is the largest tributary to NH's most significant estuary, the Great Bay estuary. Most of the estuarine waters of the Great Bay were classified as "impaired" by elevated nitrogen in 2009. Our long-term monitoring of surface waters throughout the Lamprey and Oyster watersheds complements existing Great Bay datasets and will provide necessary monitoring data to assess the effectiveness of any future management strategies to reduce the nitrogen load delivered to Great Bay.

Anthropogenic Micropollutant Inventory of Great Bay Estuary, NH

Project Type: Annual Base Grant
Project ID: 2019NH174B

PROJECT IMPACT:

This project funded a survey of anthropogenic micropollutants in the Great Bay Estuary, NH during 2019 and 2020. Data generated from this project showed the presence and concentrations of 21 pharmaceutical and personal care products (PPCPs) in four wastewater treatment facilities discharging to tributaries of the Great Bay, and six surface water locations within the Great Bay. By surveying these constituents in multiple years, we determined which PPCPs recurred in summer, and surmised the impact of COVID-19 restrictions on surface water concentrations. Among those pharmaceuticals analyzed in Great Bay Estuary surface waters in 2019, only sulfamethoxazole and carbamazepine were also detected in surface waters in 2020. Azithromycin, ciprofloxacin, fluoxetine, and trimethoprim were not detected in any surface water sample in 2020, although each was detected in one sample in 2019. A reduction in antibiotics suggests reduced occurrence of bacterial infections due to school closures and reduced social activities. In addition, despite detecting caffeine in all 6 surface water samples in 2019, this compound was undetected in 2020. These finding suggests careful evaluation of surface water sampling pre/post- COVID-19 in context with altered human behavior may assist in source tracking for surface waters receiving PPCPs from many point and non-point sources. Results also point toward a rapid response in reduced PPCP concentrations in surface waters due to lower loads from major dischargers. This project funded four female undergraduate, graduate, and post-doctoral students in STEM fields and resulted in two peer reviewed publications.

Pressure-cooked: Synergistic Impacts of Chemical, Thermal And Physical Threats To Native Brook Trout

Project Type: Annual Base Grant
Project ID: 2019NH175B

PROJECT IMPACT:

Native Brook trout densities in streams and lakes have decreased dramatically. We sought to understand how chemical, thermal and physical stressors may interact and explain behavior, distribution, and persistence of Brook trout. Nearly 2,000 Brook trout were captured, 342 trout tagged, and 533 pit tag observations were made during the project. We analyzed genetic structure from fin clips sampled in 2016 prior to fish barrier removal and 2018, one year after removal. We found Brook trout in tributaries with an impassible road crossing were genetically distinct from those in tributaries without barriers. Genetic mixture (phenotypes) within tributaries without impassible culverts were similar suggesting at least historical movement between tributaries. Observed heterozygosity differed significantly among tributaries within a given year, but not within a given tributary between 2016 (n=339) and 2018 (n=250). We attribute the lack of a notable difference to low movement rates across the tributaries since culvert removal. Based on analysis of 557 unique wild Brook Trout observed between 2017 and 2019, we found Brook trout length, benthic macroinvertebrate density, bankfull width, water temperature, water level, and wetted width explained 50% of observed variation in Brook trout growth. Finally, statistical analysis suggested the expression of heat shock protein (*ind*HSP70) in Brook trout was explained (non-linearly) by temperature and water level, with highest expression observed during cold high flow periods. Improved understanding of these interactions will support better management of this ecologically important species.

Effects of dissolved organic carbon on methylmercury bioavailability in stream ecosystems

Project Type: National Competitive Grant
Project ID: 2016NH205G

PROJECT IMPACT:

Our work has advanced understanding of how landscape and chemical parameters drive levels of methylmercury, a potent neurotoxin, in streams. Watersheds in the Northeastern U.S. are prone to high levels of methylmercury, which can bioaccumulate to toxic levels in stream biota and be transferred to downstream water bodies. In field comparisons of 27 streams across a single watershed, we found that high levels of methylmercury in stream water were most strongly associated with elevated levels of iron, aluminum, and humic-like organic carbon. Stream chemistry was related to landscape parameters, where streams draining from small lakes had more “bleached” and microbially-processed dissolved organic carbon and lower levels of methylmercury, whereas streams with wetlands in their catchments had more humic-like dissolved organic carbon and higher levels of methylmercury. In longitudinal sampling of 3 focal streams, methylmercury, iron, and dissolved organic carbon varied temporally. Methylmercury concentrations in wetland-draining streams were highest when temperatures were warm, promoting reducing conditions in watershed soils and wetlands. As such, this project identified conditions related to elevated methylmercury concentrations in streams on both a spatial and temporal scale, which is important to identifying and monitoring environments sensitive to mercury accumulation and predicting potential future changes ongoing land use and climate variability.

Determining the effectiveness of the Clean Air Act and Amendments on the recovery of surface waters in the northeastern US

Project Type: Coordination Grant funded by pass-through funds from the EPA
Project ID:
USGS Award: G18AP00030
EPA/USGS agreement: DW-014-92478401-0

PROJECT IMPACT:

This project continues the important work of the Regionalized Long-Term Monitoring program (RLTM) of the US Environmental Protection Agency (EPA) Long-Term Monitoring (LTM) Network. The RLTM program is operated through EPA's Clean Air Markets Division (CAMD) and RLTM data are incorporated with the other LTM programs to monitor chemical trends and potential environmental responses from the Clean Air Act Amendments of 1990 (CAAA) and subsequent emissions reductions programs.

This information is fundamental for EPA to meet the Congressional mandate for reporting on the effectiveness of the CAAA. The highly effective combination of site-specific data within a regional context will provide for the recognition of trends and understanding of processes relating to declining SO4, base cation depletion, and changes in N-saturation or DOC contributions to acid-base status. The results are central to the decisions on additional emission changes.

Field work, laboratory analysis, data analysis and interpretation are ongoing for 16 RLTM and 12 HELM lakes. Final 2019 data were submitted to the EPA CAMD in November 2020. Laboratory analysis of the lake samples collected in 2020 is approximately 90% complete. All sampling and analysis have followed the procedures described in the QAPP.

Evaluating Environmental DNA Lake Assessments: A potential early warning alert for the presence of cyanobacteria associated with HAB formation in New England lakes

Project Type: Coordination Grant funded by the USGS
Project ID:
USGS Award: G20AP00034

PROJECT IMPACT:

Samples were collected from multiple locations in six lakes in Maine, Vermont and Massachusetts in 2019. In 2020, research restrictions due to Covid-19 reduced the amount of sampling that could be conducted, but samples were still collected in Maine and Massachusetts. Samples were transferred to UNH for molecular analysis. All samples were extracted, and analyzed for bacterial and eukaryote sequences. We anticipate significantly more samples in 2021, and the full metadata analysis will be conducted when the data set is complete, but our initial analyses show several findings:

- The community of bacterial species present, which includes, but is not limited to cyanobacteria changes in each lake over the course of the summer. The final analysis will pair bacterial community data with lake water chemistry to better determine the relationship between bacterial community and lake chemistry.
- Lakes have very different bacterial communities from each other, and locations within each lake have different communities.
- Aerosol samples were collected in coordination with water samples in several locations. These samples have very small to undetectable amounts of cyanobacteria, indicating either that aerosolization is not occurring, or that the filter and extraction combination we deployed are not effective. We will investigate this further in 2021.