Zachary C. Johnson

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Education

Ph.D., Hydrology, University of Nevada

Dissertation title:	Effects of transient storage on solute transport and nitrogen cycling in a western U.S. river (see below for abstract)
Graduation:	August, 2014

M.S., Hydrology, University of Nevada

Thesis title:	Effect of soil moisture, soil texture and vegetation type on C and N transformations in agricultural fields of northwestern Nevada (see below for abstract)
Graduation:	May, 2010

B.A., ACS Chemistry, Concordia College-Moorhead, MN

Minor:	Mathematics
Graduation:	April, 2007 (Cum Laude)

Teaching Experience

Fall 2009 and 2010--Teaching Assistant

Hydrologic Fluid Dynamics, University of Nevada

Responsibilities:	Attend lecture, develop and grade assignments, hold office hours (lecture and homework questions), and grade exams

Research Experience

<u>Landform and climate controls on groundwater influence in headwater streams of Shenandoah National Park, Virginia (Post-doc, GS-0408/12, USGS Leetown Science Center)</u>

November 2014-present

Understanding groundwater contribution to stream temperature is critical for predicting climate effects on thermal habitat in streams. Recent studies suggest that in forested watersheds, groundwater influences on water temperature can be inferred by air-water temperature regression models. The goal of this research is to identify landscape and climate predictors of groundwater influence at the stream reach spatial scale. We examined estimates of groundwater influence at 79 sites within nine watersheds in Shenandoah National Park, Virginia, USA, over four summers (2012-2015) and determined effects of varying groundwater contribution on thermal sensitivity (extent to which stream temperature changes with unit change in air temperature). We used a GIS to derive a series of landscape factors based upon gradients in geomorphology, geology, network topology, and vegetation parameters to predict the spatial distribution of groundwater influence on thermal sensitivity during baseflow summer months and evaluated these spatial predictors using machine-learning techniques. We found that groundwater thermal influence was patchy, varying as much within as among watersheds, and that spatial variation in groundwater contribution is influenced by complex interactions among landscape and climate attributes. Moreover, although groundwater influence was relatively consistent among summers at some sites, it changed dramatically at others. This led to variation in the relative importance of space and time metrics between watersheds. There are strong indications that temporal factors, such as recent (within one year) precipitation patterns, are strongly influencing GW dynamics at our sites. A manuscript (lead author) is currently being developed that will include spatial and temporal predictors of GW influence and two recent webinars were given to the USGS NCCWSC and NPS collaborators related to this research.

<u>Stream temperature dynamics in headwater streams of Shenandoah National Park, Virginia and Catoctin Mountain Park, Maryland (Post-doc, GS-0408/12, USGS Leetown Science Center)</u>
November 2014-present
Forecasting the effects of climate change for brook trout habitat in forested headwater streams requires an understanding of how water temperature responds to changing air temperature (i.e., thermal sensitivity). Previous research developed regression models that account for groundwater influences on thermal sensitivity from measured air-water temperature relationships in forested headwater streams. The goal of this research is to identify how groundwater dynamics vary among stream reaches and how this affects stream thermal sensitivity and habitat suitability for brook trout in two areas of the mid-Atlantic region. Other research questions include; which stream reaches are most vulnerable to climate change impacts (thermal sensitivity), which reaches are currently most important for brook trout reproduction (e-fishing survey), which reaches are likely to remain suitable for brook trout, and can stream thermal sensitivity, groundwater dynamics, and surface discharge be predicted based on landform features?

<u>Using passive seismic methods to estimate depth to bedrock (Post-doc, GS-0408/12, USGS Leetown Science Center/collaboration with the USGS Branch of Geophysics)</u>
July 2015-present
Depth to bedrock in mountain headwater basins is an important control on the amount of groundwater stored and discharged to streams. Therefore, due to groundwater's impact on stream temperatures, depth to bedrock is also an important control on the stream thermal regime and thermal habitat suitability. Estimation of depth to bedrock has typically involved effort and time intensive methods such as active seismic measurements. In this investigation, new passive seismic methods were used to infer depth to bedrock properties within Whiteoak Canyon in Shenandoah National Park and how heat is transmitted between the stream and subsurface. These methods are relatively fast, present the possibility of increased spatial coverage, and have implications for future brook trout thermal habitat suitability. A manuscript (co-author) has recently been submitted to a special issue of Limnologica: Aquatic boundaries and linkages. Future work will include an expanded sampling campaign in Shenandoah National Park.

Effects of transient storage on solute transport and nitrogen cycling in a western U.S. river (Ph.D. dissertation, Desert Research Institute)

May 2010-August 2014

This dissertation describes how different types of transient storage zones affect the in-stream physical and biological transport and storage of solutes in a large stream and how this knowledge can be applied to restoration efforts. Transient storage zones provide unique habitats in streams and influence solute retention by increasing residence time and exposure to biochemically reactive surfaces. Despite the different hydraulic and biochemical characteristics of hyporheic (HTS) and surface transient storage (STS) zones, most modeling studies use a single lumped storage zone, which has likely contributed to over a decade of contradictory results regarding the relationship between transient storage and solute removal. The traditional OTIS river solute transport model was modified to include multiple storage zones (HTS and STS), calculation of uptake within each stream compartment, and Michaelis-Menten uptake kinetics. Multiple conservative and reactive tracer tests were conducted at two discharge levels in two reaches of the lower Truckee River, NV. The modified numerical model was used to fit trends in the observed data and to simulate hypothetical restoration scenarios.

STS is almost 14 times more influential than HTS on the physical transport of solutes, as measured by its influence on median transport time, because of fast exchange rates between the main channel and STS zones in the lower Truckee. HTS zones were 106 times more influential in the biological retention of nitrate due to longer residence times and greater uptake rates. Results varied between sub-reaches and were dependent on a combination of geomorphology (discharge, slope, average width, average depth, and sinuosity,) and the physical and biological characteristics of the storage zones (exchange rate, size, residence time, and uptake rate).

This work is unique in describing the physical and biological characteristics of both the hyporheic and surface transient storage zones in a large stream (> 0.5 $m^3 s^{-1}$). With only physical retention information, STS appears to dominate in-stream transient storage processes. However, when both physical and biological processes are taken into account it becomes apparent that HTS dominates in-stream nitrogen removal. Results suggest that separation of the two transient storage zones is needed for a complete understanding of solute transport, storage, and removal. This information can help guide stream restoration activities.

By simulating hypothetical restoration scenarios, this research shows that the size of the hyporheic transient storage zone is the most important factor for removing N via denitrification and that a combination of restoration targets—including increased width-to-depth ratio, sinuosity, and hyporheic size—produces more efficient N removal than the sum of the removal from individual restoration targets. In-stream N removal can also be increased by adjusting the fraction of organic versus inorganic N from a point source. A visual tool depicts the potential for stream restoration activities to significantly increase N removal via denitrification using the combination of hyporheic size, maximum denitrification rate, and half saturation concentration for denitrification.

Effects of soil texture, soil moisture, and vegetation type on C and N transformations in agricultural fields of northwestern Nevada (Master's thesis, Desert Research Institute)
January 2008-May 2010
Currently, because of the continued extraction of water from the Walker River resulting in significant water level drops and increased salinity of Walker Lake, alternative crop options and irrigation regimes are being explored to allow for agricultural practices that require less water while maintaining economic feasibility. As part of this project we studied the effects of soil moisture, soil texture and vegetation type on soil quality. We specifically focused on C and N mineralization as indices of soil quality. Field analysis focused on two alternative agriculture fields (Valley Vista and Cottonwood Ranch) in the Walker River Basin to determine the role of soil moisture, temperature and vegetation type on soil quality. Laboratory analysis focused on three revegetation (Wildlife Area, Valley Vista and Cottonwood Ranch) and two alternative agriculture fields (Valley Vista and Cottonwood Ranch) to determine the role of soil moisture, soil texture, and vegetation type on soil quality. In the short-term, none of the alternative crops grown appeared to have immediate detrimental effects on soil quality versus the traditionally grown alfalfa. In fact, the tef and amaranth crops grew quite well over the establishment season without detrimentally impacting soil C and N transformations as measured in this study. As a result, these two alternative crops have high potentials for the future in this area.

Truckee River Integrated Monitoring Program (Desert Research Institute)
May 2010-December 2011
This is a monthly data collection program for the Truckee River to monitor water-quality between Lake Tahoe and Pyramid Lake. The primary purpose of the program at that time was to provide long-term ambient water quality data to federal, state, and local agencies. My part included obtaining water quality samples at six points along the river from Lake Tahoe to Reno, NV.

Concordia College Chemistry Department, Moorhead, MN
Summers of 2005 and 2006
As part of a research group including undergraduate, post-doctoral, and faculty members, noisy light spectroscopy was used with an Nd:YAG laser together with a narrowband source to explore such techniques as Coherent Anti-Stokes Raman Spectroscopy and Four-Wave Mixing (w/o the Narrowband Source). Also, included in this research was theoretical analysis using X-marginals, Fourier Transforms, WMEL and FTC diagrams along with various other mathematical models familiar to Physical Chemistry.

Funded Proposals

Quantifying the Impact of Hyporheic Exchange on In-Stream Water Quality of the Truckee River, NV

George Burke Maxey Graduate Student Fellowship Award, Desert Research Institute of Reno, NV
Principal Investigator: Zachary C. Johnson
Award Date: 2011
Award Amount: $21,600 total for one year

Quantifying the Impact of Hyporheic Exchange on In-Stream Water Quality in the Truckee River, NV

Nevada Water Resources Research Institute Grant (USGS Grant/Cooperative Agreement Number G11AP20092)
Principal Investigator: John J. Warwick/Rina Schumer
Award Date: 2011
Award Amount: $139,519 total over two years

Publications

Johnson, Z.C., N.P. Hitt, and C.D. Snyder "New inferences on stream thermal resiliency to climate change from spatial and temporal groundwater modeling" *in preparation*.

Briggs, M.A., J.W. Lane, C.D. Snyder, E.A. White, **Z.C. Johnson**, D.L. Nelms, and N.P. Hitt "Shallow mountain bedrock limits seepage-based headwater climate refugia," *under review* with Limnologica.

Johnson, Z.C., P.S. Verburg, J.A. Arnone III, R.L. Jasoni, and J.D. Larsen "Effects of some key ecological factors on C and N transformations in agricultural fields of northwestern Nevada," *in preparation*.

Johnson, Z.C., J.J. Warwick, and R. Schumer (2015) "A numerical investigation of the potential impact of stream restoration on in-stream N removal," Ecological Engineering **83**, 96-107.

Johnson, Z.C., J.J. Warwick, and R. Schumer (2015) "Nitrogen retention in the main channel and two transient storage zones during nutrient addition experiments," Limnology and Oceanography **60**, 57-77.

Johnson, Z.C., J.J. Warwick, and R. Schumer (2014) "Factors affecting hyporheic and surface transient storage in a western U.S. river," J. Hydrology **510**, 325-339. [doi:10.1016/j.jhydrol.2013.12.037].

Johnson, Z.C. "Effects of soil texture, soil moisture, and vegetation type on C and N transformations in agricultural fields of northwestern Nevada." MS Thesis. University of Nevada, Reno, 2010. Print.

Booth, E.C., B.G. Berger, **Z.C. Johnson**, T.M. Ta, L.R. Weisel, D.J. Ulness (2006) "Analysis of Raman-enhanced nondegenerate four-wave mixing with factorized time correlator diagrams," J. Opt. Soc. Am. B **23**, 885-892.

Conference Presentations and Posters

Johnson, Z.C., N.P. Hitt, and C.D. Snyder. New inferences on stream thermal resiliency to climate change in Shenandoah National Park. USGS webinar for National Park Service collaborators. June 29, 2016. *Webinar Presentation*.

Johnson, Z.C., N.P. Hitt, and C.D. Snyder. New inferences on stream thermal resiliency to climate change from groundwater modeling. USGS National Climate Change and

Wildlife Science Center Monthly Phone Conference. June 22, 2016. *Invited Webinar Presentation*.

Johnson, Z., C. Snyder, and N. Hitt. Predicting climate change effects on brook trout at management-relevant spatial scales. Trout Unlimited Monthly Phone Conference. June 15, 2016. *Invited Webinar Presentation*.

Johnson, Z., C. Snyder, and N. Hitt. Predicting climate change effects on brook trout at management-relevant spatial scales. Trout Unlimited Southeast Regional Meeting, Roanoke, VA. May 21, 2016. *Invited Presentation*.

Hitt, N.P., C.D. Snyder, **Z.C. Johnson**, E. Snook, and L. Donaldson, New sampling design reveals hotspots for brook trout recruitment in Catoctin Mountain Park. Spotlight on National Park Resources in the National Capital Region, National Conservation Training Center, Shepherdstown, WV. April 21, 2016. *Contributed Presentation*.

Johnson, Z.C., N.P. Hitt, C.D. Snyder, Landscape predictors of groundwater influence on stream temperature in forested headwater catchments. AGU Fall Meeting 2015, San Francisco, CA. *Poster*, H23H-1664.

Johnson, Z.C., N.P. Hitt, C.D. Snyder, Modeling thermal effects of climate change from landform predictors of groundwater influence in Chesapeake Bay headwater streams. GSA Annual Meeting 2015, Baltimore, MD. *Presentation*.

Hitt, N., C. Snyder, J. Young, **Z. Johnson**, E. Snook, Forecasting environmental change: modeling thermal refugia and brook trout abundance. Appalachian LCC Northeast Region Brook Trout and Stream Termperature Modeling Workshop 2015, Hadley, MA. *Contributed Presentation*.

Johnson, Z.C., R. Schumer, J.J. Warwick, Relative influence of hyporheic and surface transient storage on total N uptake kinetics. AGU Fall Meeting 2013, San Francisco, CA. *Poster*, B11C-0389.

Johnson, Z.C., J.J. Warwick, R. Schumer, Physical and biological N retention in two transient storage zones of the Truckee River, NV. UCOWR/NIWR Conference 2013, Lake Tahoe, CA. *Poster*.

Johnson, Z.C., R. Schumer, J.J. Warwick, Physical and biological N retention in two transient storage zones of the Truckee River, NV. AGU Fall Meeting 2012, San Francisco, CA. *Poster*, H13D-1379.

Johnson, Z.C., R. Schumer, J.J. Warwick, Hyporheic exchange in geomorphically distinct sections of the Truckee River, NV. AGU Fall Meeting 2011, San Francisco, CA. *Poster*, H41F-1108.

Johnson, Z.C., Incorporating new data into an existing water quality model of the Truckee River. NWRA Truckee River Symposium 2011, Reno, NV. *Presentation*.

Johnson, Z.C. and P. Verburg, Effects of soil moisture, soil texture, and vegetation type on C and N mineralization. UNR Student World Water Forum, Reno, NV. *Presentation*.

Professional Affiliations and Service

American Geophysical Union, *member* – 2011 to present
Journal of Hydrology, *reviewer* – 2015 to present
Aquatic Sciences, *reviewer* – 2015 to present

Water Resources Research, *reviewer* – 2016 to present

Data Analysis

R (Statistical computing and graphics software, experienced)
ArcGIS (Geographic information system software, experienced)
Python (Programming language, some experience)
Whitebox (Geographic information system software, some experience)
DataDesk™ (Statistical analysis software, experienced)
FORTRAN (Computer programming language, experienced)
MATLAB (Numerical computing software, some experience)
OTIS (USGS transient storage transport model, proficient)
MODFLOW (USGS finite-difference groundwater model, some experience)
WASP (USEPA transport and eutrophication model, experienced)
HSPF (USEPA watershed hydrology and water quality model, some experience)
EcoWatch (YSI sonde interface software, experienced)
WinRiverII (Teledyne RDI interface software, experienced)
Microsoft Office programs including Word, Excel, and PowerPoint (proficient)

References

Dr. Than Hitt (USGS-Leetown supervisor): nhitt@usgs.gov, (304) 724-4463
Dr. Craig Snyder (USGS-Leetown colleague): csnyder@usgs.gov, (304) 724-4468
Dr. John Warwick (Ph.D. advisor): warwick@siu.edu, (618) 453-7748
Dr. Rina Schumer (Ph.D. co-advisor): Rina.Schumer@dri.edu, (775) 673-7414
Dr. Paul Verburg (Master's advisor): pverburg@cabnr.unr.edu, (775) 784-4019