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Published in *Creating Tomorrow – Oct. 15, 2016 –* When it comes right down to it, scientists and environmental engineers will tell you that nearly every ecosystem on Earth is driven by one simple thing: temperature.

Oceans, rivers, forests and deserts are a product of the chemical and biological processes that depend on a predictable mix of hot and cold. Even in the Arctic, where shallow soils are frozen most of the year, tiny variations in temperature can impact entire regions.

Tyler King and Beth Neilson prepare a midnight tracer injection in the Kuparuk River in 2015.

For the past seven years, Bethany Neilson has spent part of her summers in the Arctic, wading through the chilly waters of Northern Alaska – about 68 degrees north latitude at the Toolik Field Station. Neilson, an associate professor of civil and environmental engineering, and an alumna of Utah State, is among the first to investigate what's happening to stream and river temperatures in watersheds in some of the coldest places on earth. She and her students are trying to understand what dictates water temperature in the Arctic and how climate change could impact the delicate ecosystems there.

"We wanted to know how in-stream temperatures will vary with climate change," she said. "We're trying to better understand how water moves through these landscapes and understand its influence on arctic streams and rivers under current conditions."

But it turns out there had been little to no research done in Arctic basins about what controls temperatures in rivers. Using a small team of USU and University of Alaska Fairbanks student researchers, a grant from the National Science Foundation and a helicopter, Neilson set out to place hundreds of in-stream sensors along stretches of the lower Kuparuk

River basin and through a smaller headwater basin, Imnavait Creek on Alaska's North Slope. Knowing how temperature changes – and *when* it changes – is key to understanding how these unique arctic watersheds work.

"Temperature is very important for any kind of biological or chemical process," she added. "For example, it affects fisheries and nutrient fate and transport within streams, rivers and lakes."

Neilson is a USU alumna ('98, '01, '06) who currently works as an associate professor of civil and environmental engineering.

Much of the ground is frozen year round, and summertime temperatures thaw only one or two feet of the soils – three feet at most near rivers. The resulting temporary aquifer in these shallow soil layers, accompanied by summertime rain showers, can quickly fill Alaska's rivers and streams with surging cold water – the lifeblood of downstream fisheries.

This cold water makes its way to the rivers by running over the land surface, but it also flows underground through the shallow aquifer. As flow diminishes, experience teaches us that the stream's temperatures would rise.

"When I saw how low the flows get during dry periods, I questioned how the water temperature remained viable for the fisheries," said Neilson. "When similar conditions occur in most environments, the water becomes too warm and it stresses the fish."

But arctic watersheds have an extraordinary ability to defy conventional patterns. Even when flow slows to a trickle, water temperature remains relatively low.

"Because much of the ground remains frozen at shallow depths, we found that the water entering rivers and streams from the landscape remains cold," she added. "Similarly, water moving through the sediments below and adjacent to the stream is influenced by the frozen ground and creates a significant net cooling effect. This means that even when the rivers have very low flow, they remain cool."

Tyler King places sensors in the Kuparuk River, Alaska in July 2015.

For Neilson and her team, including PhD student Tyler King, the next question becomes: what will happen when air temperatures in the Arctic rise and the soils thaw deeper and deeper into the frozen tundra?

“What we’re finding is that the influence of water draining from the landscape is significant during periods of rain, but the exchange of water and heat with sediments adjacent to the river and the proximity of frozen soils appear to buffer temperatures during low flows,” she said. “While our main focus has been on the thermal influences of these inflows, they also control the delivery of carbon and nitrogen to the rivers and the Arctic Ocean.”

Because warming at high latitudes will affect the entire planet, Neilson’s research will help show us how connected we are to the Arctic.

“There are some very interesting feedbacks in these systems,” she added. “What happens up there, impacts what happens here. The connectedness between polar systems and our daily lives is indirect but you can’t disconnect them.”

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