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Healthy river systems depend on protected headwaters

Using measurements collected by the governments of Alberta, Saskatchewan and Canada over the last 20 to 40 years, Dr. Sarah Ellen Johnston, a post-doctoral fellow at the University of Lethbridge, and Canada Research Chair Dr. Matthew Bogard have mapped out changes in the flow of carbon through the South Saskatchewan River Basin (SSRB) in a study that was recently published in Geophysical Research Letters.

"What happens in the mountain headwaters has huge implications for us down here in the prairies," says Johnston. "Our big takeaway from this study was that a lot of the carbon comes from the mountains, so we really need to consider those headwater sources of carbon as the main energy and fuel sources to the food webs in the rest of our watershed. If we don't want to see big changes in organic carbon, we need to protect the headwaters."

The organic form of carbon, the focus of this research, is an important indicator of the health of river systems. Too little carbon or a rapid decline in carbon content lowers the ability of a river to sustain life, while too much carbon or a rapid increase has ramifications for drinking water and other important ecosystem services. While some carbon sources come from within a river system itself, such as bacteria and algae, carbon also enters river systems from the landscape, through trees, plants and soils. For rivers in the SSRB, including the Bow, Oldman and Red Deer sub-basins, the typical pattern is a surge in carbon during the spring snow melt.

"An exciting discovery in recent decades is that rivers and lakes intercept an enormous amount of the carbon moving off the land toward the oceans," says Bogard. "What happens in Canada's rivers impacts the balance of carbon in our atmosphere. Our study adds new numbers to this, which is like adding a piece to help solve the global carbon budget puzzle. The better we understand the global carbon cycle, the better we can help guide society in terms of cost-effective climate-change mitigation strategies."

“In general, Alberta is doing quite a good job of protecting the headwaters by having them designated as parkland,” Johnston says. “There’s a push to change that, but maintaining the protection of these headwaters will help to maintain the energy source for the rest of the river systems.”

The SSRB originates in the Rocky Mountains and covers about 146,000 square kilometres of southern Alberta, Montana and Saskatchewan. The region shows large shifts in land cover and development, as well as in water usage and allocation. For example, southern Alberta, with its agricultural base, has high proportions of water withdrawal from its rivers.

“We wanted to determine whether there have been changes over time in the flow of organic carbon through these river systems,” she says. “If humans are causing particular decreases or increases, then that’s really where we start to see issues. So, if we start having things like coal mines, for instance, up in the mountains, then mine waste and disturbances to the pristine watersheds can have cascading effects in the rivers and affect downstream ecosystems.”

Along with Johnston, a U.S. National Science Foundation Earth Sciences-funded post-doctoral research fellow, and Bogard, the research team included graduate student Panditha Gunawardana and professor emeritus Dr. Stewart Rood. They used publicly available measurements of both organic carbon content and the amount of water flowing through the SSRB rivers. Their goal was to model how much carbon moves through these systems and whether those patterns have changed over the years. The data captured the extremes of river conditions, including severe droughts and flooding.

“What we found is that, through time, carbon fluxes, or the movement of carbon, hasn’t really changed directionally,” says Johnston. “Unlike in many other regions of the world, it’s not going up or down. We found that the land cover — whether it’s forested, or prairie or agricultural land — is really what determined how much carbon we saw moving through the rivers.”

In more forested systems, such as in the mountains, a lot more carbon and water were present than in grasslands and agricultural systems. The researchers also examined differences between years and found that climate oscillations, such as El Niño, have a large impact on the flow of carbon through the SSRB.

“We found that climate oscillations are really important in determining how much carbon is moving through our rivers each year,” says Johnston. “It’s linked to larger climate processes, which are getting more erratic with climate change.”

The findings could have implications for understanding mountain-to-grassland transitional ecosystems around the world. The research was funded by the U.S. National Science Foundation, the Natural Sciences and Engineering Research Council, the Canada Research Chairs program, the U of L and Alberta Innovates.

This news release and accompanying video can be found online at headwater health.

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Contact
Caroline Zentner, public affairs adviser
University of Lethbridge
403-394-3975 or 403-795-5403
caroline.zentner@uleth.ca