

The role of boreal streams and small rivers in the carbon cycle

Streams and small rivers are characterized by a continuous movement of water which carry dissolved substances and suspended particles. These constituents come essentially from the drainage basin or the watershed, which represents the total surface of the territory that flows into a given river. Hydrologic, chemical and biological properties of such an aquatic system consequently reflect the climate, the geology and the vegetal cover of the watershed.

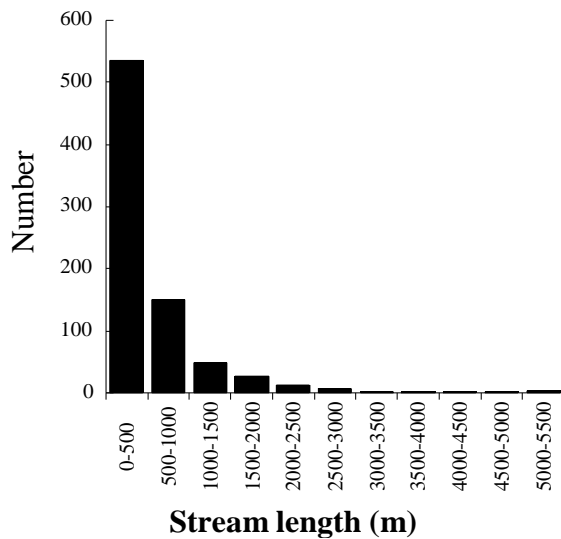
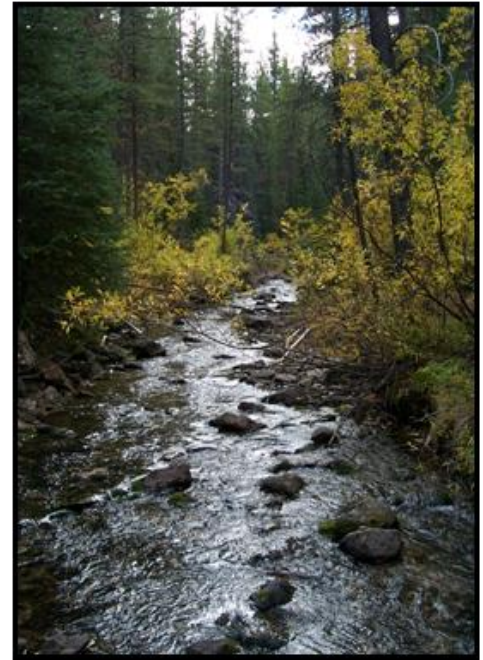


Figure 1 : Number of streams based on the length of these streams

Boreal ecosystems are known as the second largest biome of the world, representing 22% of the total forest area. Streams and rivers represent, for their part, 1% of the total Quebec boreal biome surface. By linking the numerous lakes and wetlands of the boreal region (Figure 1), small size streams (hundred to several thousands kilometres in length) dominate this wide water-resource system network (see diagram). It is a well known fact that boreal aquatic systems play a key role in the global cycle of carbon but the amplitude of greenhouse gas emissions such as carbon dioxide (CO₂) and methane (CH₄) must eventually be better defined for several types of landscapes.

Streams and carbon cycle

In comparison with boreal lakes where mineralization of dissolved organic carbon (DOC) via respiration plays a major role, input of inorganic carbon from the earth to the water dominates the carbon budget in small streams. In fact, carbon in these aquatic systems mainly comes from biological processes such as the respiration of micro-organisms, which is present in terrestrial ecosystems. This direct dissolved inorganic carbon (DIC) input plays a significant role in the concentrations of CO₂ measured in the water surface of streams (Figure 2).

Other sources of DIC may influence the fluctuations in pCO₂, such as the respiration in the sediments and in the water column as well as algae photosynthesis. In fact, DOC is a major source of carbon for streams heterotrophs. However, in many systems, bacteria and mushrooms are found to be limited in carbon, probably since carbon of terrestrial origin is often less labile, thus of lower quality than the one originating from algae and aquatic plants.

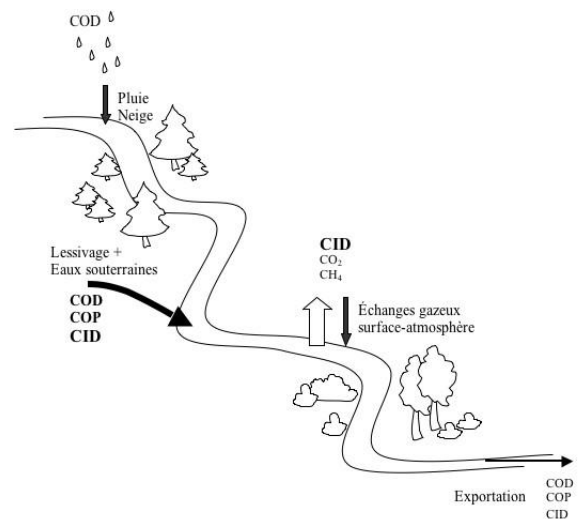


Figure 2 : Diagram of carbon exchanges in streams and rivers

Eastmain streams adding to our knowledge!

The Eastmain Project contributed to the advancement of our knowledge on boreal streams. During the summers 2005 and 2006, 70 streams of different sizes were visited and sampled at the physico-chemical and biological level (Figure 3).

Concentrations of surface CO_2 (pCO_2) measured in the streams over the course of this study show that these systems tend to be hyper saturated in CO_2 and thus represent a source of this greenhouse gas in the atmosphere. Results also demonstrated that CO_2 patterns are showing considerable variations at the spatial and temporal levels. In fact, these spatial variations can be explained by the closer relationship that exists between the watersheds, their vegetation and their streams, which makes the latter as changing as the physiology of a landscape, its productivity or the geology of the terrestrial basin. On the temporal level, we must note that the chemistry and the abundance of precipitation alone can considerably alter the properties of a small stream. It is thus sensible to observe a seasonal fluctuation in the pCO_2 of these tributaries. Researchers have also established a link between certain chemical properties of the water, certain physiological aspects of streams and surface pCO_2 .

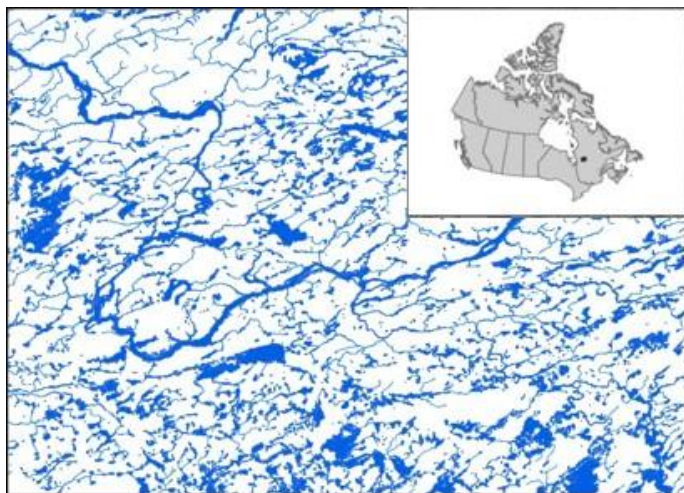


Figure 3 : The water-resource system network of the Eastmain-1 reservoir area

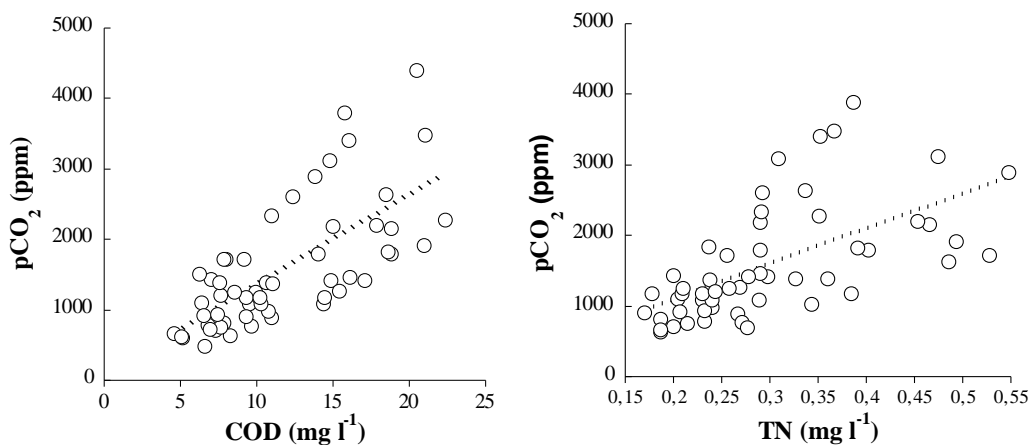


Figure 4 : Concentration of CO_2 in the water (pCO_2) based on the concentration of dissolved organic carbon (DOC) or of total nitrogen (TN) in the water.

It has been demonstrated that patterns of DOC and of total nitrogen (TN) explain rather well the variations observed in pCO_2 (Figure 4). We can then presume that the decomposition processes that use these sources of carbon and nutrients within the aquatic system also take a non-negligible part in the measured gas concentrations. Furthermore, the length of the stream could also give an indication of its CO_2 content. Most streams are connected to adjacent lakes and thus are influenced by the overflows of these lakes. A smaller stream segment would be more reflective of the climatic conditions of a lake upstream while longer segments would be further influenced by carbon originating from terrestrial watersheds (Figure 5). This simple relationship between the length of a stream and its surface pCO_2 could probably make the extrapolation of concentrations of gas within similar landscapes possible and thus facilitate the estimation of the role of streams in the natural emissions of greenhouse gases.

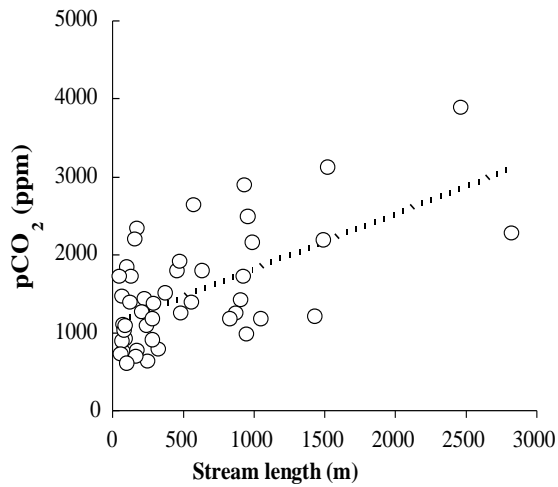


Figure 5 : Variations of CO₂ concentrations in the water (pCO₂) based on the length of the stream.

The patterns of surface CO₂ in these complex Quebec boreal stream networks have rarely been studied until now. This research, conducted in conjunction with Hydro-Quebec, comes within the scope of continuous work aimed at better understanding the role of streams in the carbon budget. We hope that other studies from other types of landscapes will further add to our knowledge in order to shed light on the problematic of the natural dynamics of greenhouse gases.



Figure 6 : Sampling of water in streams

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