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Authors: Keller, Wendel (Bill), Paterson, Andrew M., Rühland, Kathleen M., and Blais, Jules M.

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Introduction—Environmental Change in the Hudson and James Bay Region

*Wendel (Bill) Keller**
Andrew M. Paterson†
Kathleen M. Rühland‡ and
Jules M. Blais§

*Corresponding author: Cooperative Freshwater Ecology Unit, Laurentian University, Ramsey Lake Road, Sudbury, Ontario, P3E 2C6, Canada
†Ontario Ministry of the Environment, Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, Ontario, P0A 1E0, Canada, bkeller@laurentian.ca
‡Paleoecological Environmental Assessment and Research Laboratory (PEARL), Department of Biology, Queen's University, Kingston, Ontario, K7L 3N6, Canada
§Department of Biology, University of Ottawa, Ottawa, Ontario, K1N 6N5, Canada

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There are two distinct views of the north: one as frontier, the other as homeland.

–*Thomas Berger (Berger, 1977)*

The general study region examined in this special issue is the drainage to the southern portion of Hudson Bay and James Bay, which together comprise the world's largest polar inland sea. This area is vast, spanning the northern areas of three Canadian provinces, Manitoba, Ontario, and Québec. It is sparsely populated, with the most northerly areas almost solely the home of First Nations and Inuit peoples who have a close attachment to the land and a strong dependence on natural resources. The region is unique, containing the southernmost non-alpine tundra and southernmost population of polar bears (*Ursus maritimus*) in North America. The immense peatlands and extensive permafrost areas are a globally significant store of carbon. Despite the uniqueness and importance of the Hudson and James Bay region, its ecosystems have been greatly understudied (Far North Science Advisory Panel, 2010; Abraham et al., 2011).

The Hudson and James Bay region covers parts of two of the major physiographic regions in Canada, the Canadian Shield and the Hudson Bay Lowlands (Fig. 1). The Canadian Shield, defined by its hard, weathering-resistant Precambrian bedrock, is a glacially scoured landscape, sometimes with high relief, covered in lakes and rivers. Further north is the Hudson Bay Lowlands Physiographic Region, stretching from Manitoba to Québec, mainly along the western edge of Hudson Bay and James Bay. Here, Paleozoic and Proterozoic sedimentary bedrock, a legacy from marine inundation, slopes gradually to the coast, and numerous former beachfronts are evident far inland. The flat, low elevation terrain and poor drainage result in the development of the largest wetland complex in North America, and the second largest (after Siberia) northern wetland system in the world. Thousands of lakes and ponds dot the landscape. Large rivers, many with their headwaters on the Shield, flow through the Lowlands to Hudson Bay and James Bay.

The cold conditions in this relatively southern subarctic region are largely due to Hudson Bay and the persistence of sea ice on this large inland sea, the effect of which extends far inland (McKendry and Roulet, 1994). The region has very low year-round average temperatures for its latitude. For example, the average annual temperature at Churchill, Manitoba (59°N) is –5 °C in comparison to Arkangelsk in northern Russia (64°N), which has an average temperature of +2 °C. Unlike most Arctic and subarctic regions of the world, paleolimnological evidence suggests that climate in the Hudson Bay region has been particularly stable over at least the past few hundred years and likely longer (Pienitz et al., 2004).

Because of its remoteness, the Hudson and James Bay region has remained relatively inaccessible and largely undisturbed by anthropogenic activities throughout most of history. There has been natural change, of course, very slow change as the land has risen after the retreat of the glaciers and recession of the Tyrrell Sea. Some areas close to Hudson Bay exhibit the highest rates of isostatic rebound in the world. A number of the papers contributing to this special issue address the long-term changes that have occurred over the past thousands of years. In this issue, O'Reilly et al. (2014) reconstruct vegetation succession patterns and carbon accumulation at a fen site in the Attawapiskat River drainage in northern Ontario since its emergence from the Tyrrell Sea. Holmquist et al. (2014) examine the magnitude and rate of carbon accumulation since peatland initiation at a variety of sites across the Hudson and James Bay Lowlands. Fillion et al. (2014) examine the development of palsa fields in subarctic Québec near Whapmagoostui-Kuujjuarapik and investigate factors affecting the changes that have occurred. Cayer and Bhiry (2014) reconstruct post-glacial evolu-

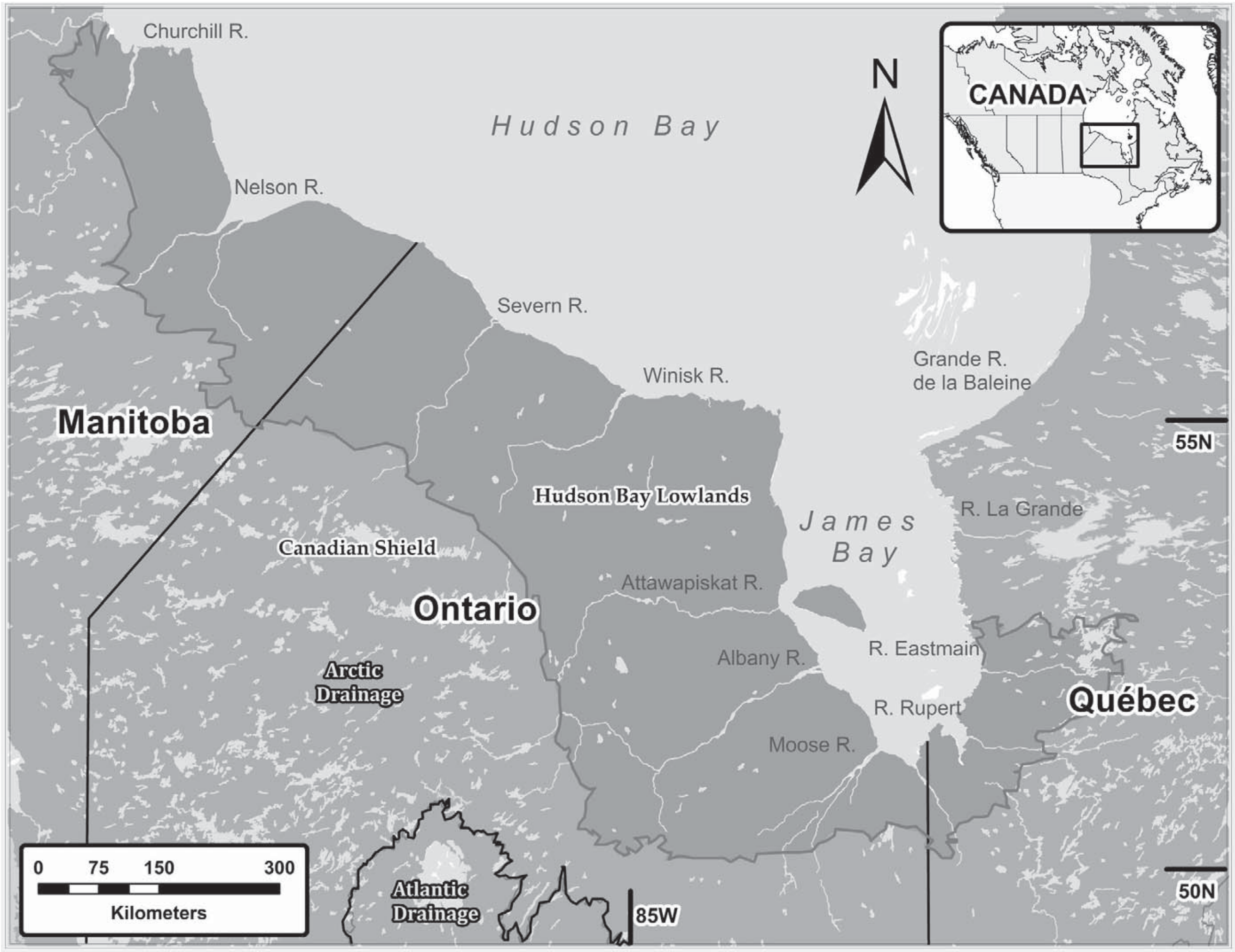

FIGURE 1. Map of the general study region showing Canadian provinces, physiographic regions, and the arctic watershed divide.

tion of the landscape near Lake Kaapumtikumac, northern Québec, using geomorphology and lake sediment data.

However, now the Hudson and James Bay region faces a much faster pace of change. Over the past few decades the cold, relatively stable climatic conditions typical of the region have given way to a clear warming trend (Gagnon and Gough, 2005; Hochheim and Barber, 2010; Bhiry et al., 2011). In this issue, Hochheim and Barber (2014) update the ice climatology of the Hudson Bay system and document large recent changes in the extent and duration of sea ice on Hudson Bay, which have led to greatly increased air temperatures. These recent changes in ice phenology and air temperature in the Hudson Bay system have large implications for terrestrial and aquatic ecosystems in the region.

As well, resources in the north are being exploited, particularly for hydropower generation and mineral extraction, and for forest harvesting in more southern areas. Demands for natural resource based developments are continuing, large regional developments that will have important consequences for many northern ecosystems. Although the Hudson and James Bay drainage is vast in size and remote, it is also not protected from large-scale, global anthropogenic stressors. Long-range atmospheric transport of contaminants, like mercury, to northern ecosystems is an important ongoing concern (Brazeau et al., 2013). And, the overarching reality of a changing climate makes the future uncertain for northern ecosystems and northern peoples. It is certain that major environmental changes in the north are coming, and that some are already happening, as papers in this special issue demonstrate. The remaining papers in this special issue document the current status of terrestrial and aquatic ecosystems, investigate recent changes that have occurred, and determine some likely future changes.

Extensive peatlands are a dominant feature of much of the study area. In this issue, McLaughlin and Webster (2014) review the peatland literature and propose potential climate change indicators and hypotheses of climate change effects that may influence peatland carbon budgets in northern Ontario. Also in Ontario, Humphreys et al. (2014) compare the CO_2 flux between a temperate ombrotrophic bog and bogs in the Hudson Bay Lowlands, and identify site characteristics related to CO_2 flux. Tam et al. (2014) use current climate data and future climate projections to predict the future distribution of palsas in northern Ontario.

Another dominant feature of the Hudson and James Bay drainage is open water. Innumerable ponds, lakes, rivers, and streams cover much of the landscape. Surprisingly, given their abundance, ecological significance, and importance to northern peoples, these aquatic ecosystems have been little studied. Paterson et al. (2014) provide first assessments of water chemistry, and zooplankton and phytoplankton assemblages in lakes of the Hawley Lake–Sutton River area, near the western Hudson Bay coast in Ontario. Analyses of a number of paleolimnological indicators in lake sediments from this region demonstrate that substantial climate-related change has already occurred in lake communities (Rühland et al., 2014). Symons et al. (2014) examine the factors potentially affecting the composition of zooplankton communities in Wapusk National Park on the western coast of Hudson Bay in Manitoba. Eichel et al. (2014) employ experiments with microcosms to assess the effects of pulses in nutrient concentrations, a possible consequence of climate change, on planktonic and benthic algal communities in Wapusk National Park. Also in Wapusk Park, MacDonald et al. (2014) examine the effects of high populations of lesser snow geese (*Chen caerulescens caerulescens*) on the hydrological, limnological, and biogeochemical conditions in ponds.

Flow characteristics may directly affect the chemical and resultant biological conditions in surface waters. To date very little is known about the hydrology of subarctic peatlands and how the nature, extent, and distribution of surface waters may have changed or will be likely to change. White et al. (2014) demonstrate linkages between hydrological connectivity and seasonal limnological patterns in ponds in the Hudson Bay Lowlands, Manitoba. Orlova and Branfireun (2014) apply a chemical mixing model approach to investigate runoff-generating processes in peatland streams in the Attawapiskat River drainage, northern Ontario. Bouchard et al. (2014) and Macrae et al. (2014) use field measurements and remote sensing data to examine temporal changes in the distribution of ponds in northern Québec, and northern Manitoba, respectively.

The papers in this special issue add substantially to our knowledge on terrestrial and aquatic ecosystems in the Hudson and James Bay region. They reveal how various aspects of these systems have changed in the past, what they are like now, and how they are likely to change in the future. Many of these papers provide important assessments of baseline or reference conditions, which will permit evaluations of future changes.

However, much work still needs to be done to provide the necessary science on which to base wise resource management decisions. These, in turn, will be required to effectively manage and protect this vast, globally important area. One of the most complex questions and one of the most compelling is, How will northern peoples be best able to adapt to the environmental changes in the landscape? It is our hope that multidisciplinary northern science, as presented in this special issue, will help with understanding and meeting the future challenges of living in the North.

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