Review of Palaeobotany and Palynology 174 (2012) 48–56

Contents lists available at SciVerse ScienceDirect

Review of Palaeobotany and Palynology

journal homepage: www.elsevier.com/locate/revpalbo

Research paper

Calibration of pollen assemblages and carbon–nitrogen ratios to discriminate boreal wetland types

I. Florin Pendea *, Gail L. Chmura

Department of Geography, McGill University and Global Environmental and Climate Change Centre, 805 Sherbrooke Street West, Montreal, Quebec, Canada H3A 2K6

ARTICLE INFO

Article history:
Received 8 June 2011
Received in revised form 22 November 2011
Accepted 8 December 2011
Available online 16 December 2011

Keywords:
James Bay
tidal marsh
fen
bog
discriminant analysis

ABSTRACT

Differentiation of boreal wetlands in the palaeo record is required for studies of isostacy and sea level change, landscape change, and climate dynamics. To develop palynomorph signatures and calibrate soil C–N ratios for boreal wetlands we sampled low and high elevation tidal marshes, fens and bogs along eastern James Bay, Canada. A discriminant analysis model showed that a small subset of palynomorph taxa can effectively discriminate between the four wetland types. Cyperaceae, Poaceae, and *Potamogeton*–*Triglochin*-type are important to the classification of high marshes. Bryidae spores and pollen of *Myrica gale*, Cyperaceae, and Poaceae are indicative of fen. Moss spores alone, primarily from *Sphagnum*, but also Bryidae type spores, derived from brown mosses are the indicators of bog. The use of palynomorph assemblages to discriminate among wetland types is not dependent upon the localized presence of a plant source — as it would be using macrofossil analysis. C/N of bog soils can be clearly distinguished from fen and tidal marshes and can be used as a pollen-independent proxy to indicate fen to bog wetland succession.

1. Introduction

Differentiation of boreal wetlands in the palaeo record is required for studies of isostacy and sea level change, landscape change, and climate dynamics. For instance, rates of isostatic rebound are most precisely determined by dating palaeo-tidal wetland deposits that developed as marine shorelines emerged from the sea after crustal depression by ice sheets (e.g., Shennan et al., 1999, 2000; Pendea et al., 2010). Precise dating of this phenomenon is key to understanding present day crustal adjustments and future sea level change (Peltier, 2004). Continued crustal uplift isolated these wetlands from tidal influence, transforming them from tidal wetlands to freshwater wetlands. Such landscape changes had, and are still having impacts on habitat available to wildlife and resources available to indigenous populations. Continued accumulation of wetland deposits eventually isolates the ecosystem from groundwater, resulting in a shift from a minerotrophic fen to an ombrotrophic bog.

As wetland transition occurs, the rates of carbon storage in soils and greenhouse gas flux change significantly. Tidal marshes store an average of 210 g C m^{-2} yr^{-1} (Chmura et al., 2003), and northern freshwater peatlands globally average 20–30 g C m^{-2} yr^{-1} (Roulet, 2000) with distinctive differences observed between bogs and more nutrient-rich fens. For example, Tolonen and Turunen (1996) reported 25.5 ± 0.5 g C m^{-2} yr^{-1} and 17.2 ± 0.3 g C m^{-2} yr^{-1}, for a Finish bog and fen, respectively. Emissions of CH_4 are low in tidal systems, moderate in bogs and probably highest in rich fens (Bartlett and Harris, 1993; Almquist-Jacobson and Foster, 1995; Magenheimer et al., 1996; Dällenbach et al., 2000; Christensen et al., 2003), although documentation of greenhouse gas flux in wetlands other than bogs and poor fens is still limited. Post-glacial development of these boreal wetlands or "northern peatlands" has played a key role in shifts of atmospheric concentrations of CO_2 and CH_4. For instance, the sustained peak in the atmospheric concentrations of CH_4 and a slight reduction of CO_2 during the early Holocene have been attributed to higher productivity associated with greater seasonality (MacDonald et al., 2006; Yu et al., 2011).

The boreal peatlands of the Hudson Bay and James Bay lowlands have been the subject of numerous palaeoenvironmental studies (e.g., McAndrews et al., 1982; Tarnocai, 1982; Klinger and Short, 1996; Glaser et al., 2004; Beaulieu-Audy et al., 2009). The initial tidal marsh phase is recognized by some researchers who note pollen of indicator tidal marsh taxa in their diagrams (e.g., Glaser et al., 2004). However, many reports only address the initiation of the "peat-forming" environment, generally associated with the fen and bog stage. Investigators commonly recognize these changes through additional studies of plant macrofossils. Shifts from fen to bog also are assumed to result in an increasing carbon–nitrogen ratios (Glaser et al., 2004), albeit this ratio has yet to be calibrated with a range of surface deposits from tidal marsh to bog.

Since the transition of nutrient rich fen to poor fen to bog follows the widely recognized model of hydrarch succession (e.g., Shimwell,

---

* Corresponding author at: Department of Interdisciplinary Studies, Lakehead University, Orillia Campus, 500 University Avenue, Orillia, Ontario, Canada L3V0B9. Tel.: +1 705 330 4008x2653; fax: +1 705 329 4035.

E-mail address: ifpendea@lakeheadu.ca (I.F. Pendea).

0034-6667/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.revpalbo.2011.12.003

1971; Mitsch and Gosselink, 1986; Glenn-Lewin and van der Maarel, 1992; Charman, 2002) some studies do not rigorously search for palynological evidence of wetland change after the first appearance of bog. However, a number of investigators have recognized that the bog phase is not necessarily a stable climax endpoint within these freshwater peatlands, and systems may alternate multiple times between fen and bog during their Holocene history (e.g., Hughes and Dumayne-Peaty, 2002). Recognition of these shifts is essential to understand that portion of the global carbon cycle attributed to northern peatlands over the Holocene.

Our study develops palynomorph signatures to detect shifts in boreal wetland ecosystems and to calibrate C/N ratios of boreal wetland soils to help refine palaeoenvironmental reconstructions of these globally important ecosystems. Our potential modern analogues come from wetlands within 100 km of the marine coast of eastern James Bay where isostatic rebound is still occurring (Pendea et al., 2010). This region provides modern wetlands that we expect to be typical of those that occurred throughout the Holocene. Our investigation includes pollen and plant spores as well as dinoflagellate cysts.

Application of modern analogues for the reconstruction of wetlands has been minimal as compared to terrestrial and marine ecosystems. Modern pollen assemblages are regularly used for reconstruction of terrestrial environments and climate parameters associated with them (e.g., Overpeck et al., 1985; Viau and Gajewski, 2009). Assemblages of dinoflagellate cysts in surface marine sediments are regularly utilized in transfer functions to reconstruct past sea surface temperatures, salinity, sea ice cover and nutrient regime (e.g., de Vernal et al., 2001; Levac, 2003; Pospelova and Chmura, 2004). The few studies which have compared pollen assemblages in surface wetland deposits have shown the ability to differentiate marsh types in the Everglades (O'Neal et al., 2001; Willard et al., 2001), swamp communities in Ontario (Bunting et al., 1998) and vegetation zones within cold temperate salt marshes (Beecher and Chmura, 2004).

2. Materials and methods

2.1. Study area and field work

The study region is located in the high-boreal zone of eastern James Bay, north-eastern Canada (Fig. 1) spanning from 0 to 198 m a.s.l. The region was covered by the last remnants of the Laurentide Ice Sheet until the early Holocene when marine waters invaded the newly deglaciated surface (Dyke et al., 2003). The marine transgression was brief and was followed by shoreline regression under the influence of glacio-isostatic rebound. A progressive landscape emergence (chronosequence) from east to west began ~7000 years ago and is still underway (Pendea et al., 2010). The region is situated within the discontinuous permafrost zone, although none of our wetland sites were underlain by permafrost.

The climate is continental subarctic, with a mean January temperature of −23 °C and mean July temperature of 14 °C (Environment Canada, 2011). Annual precipitation reaches ~700 mm, of which one-third falls as snow. The regional vegetation consists of open boreal forest dominated by black spruce (*Picea mariana*), with Jack pine (*Pinus banksiana*), alder (*Alnus viridis* subsp. *crispa*, *A. crispa* and *A. incana*), tamarack (*Larix laricina*), and dwarf birch (*Betula glandulosa*) as secondary constituents (Blondeau, 2009). In coastal areas, white spruce (*Picea glauca*) is locally dominant.

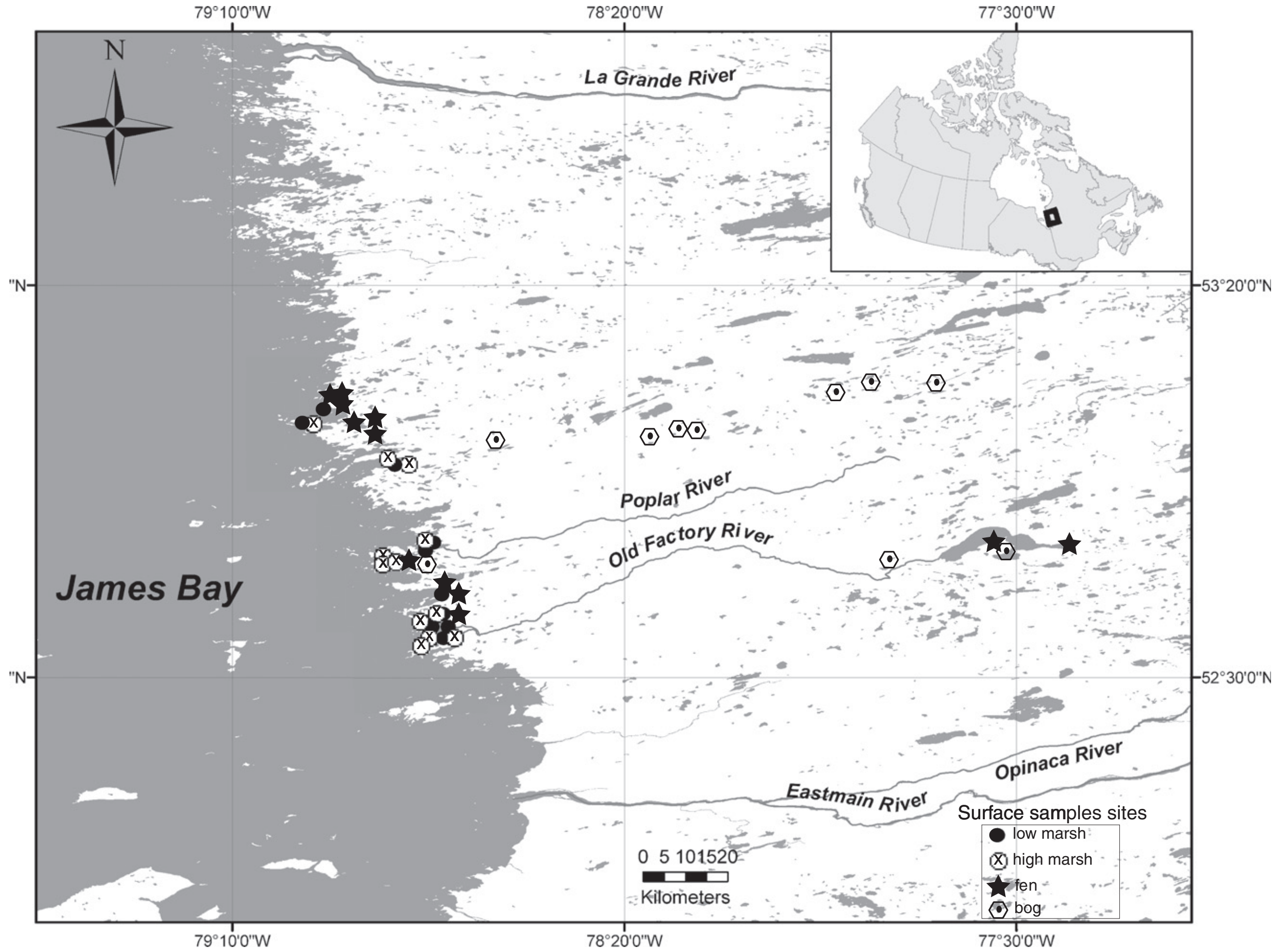

Fig. 1. Map of Eastern James Bay showing the sites where surface wetlands soils were collected. Different symbols indicate the wetland types present at each site.