

Open File OF2024-5

Palynological analyses of subfossil sediments from eleven sites in the western Hudson Bay Lowland region of Manitoba (parts of NTS 54B, 54C, 54E, 54F)





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**Palynological analyses of sub till sediments from eleven
sites in the western Hudson Bay Lowland region of
Manitoba (parts of NTS 54B, 54C, 54E, 54F)**

**by Dalton, A.S., Finkelstein, S.A., Hodder, T.J. and Gauthier, M.S.
Manitoba Geological Survey
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Front cover photos:

Intertill marine sediments exposed at section 112-19-608 (left) and an intertill organic-rich bed at section 112-19-601 (right) that were investigated for pollen analysis.

Abstract

During the 2019–2021 field campaigns, 17 samples from 11 subglacial sites in the western Hudson Bay Lowland were collected for pollen analysis. When adequately preserved, pollen records contain useful information for reconstructing past climate during ice-free intervals. Unfortunately, only 4 of the 17 examined samples contained adequately preserved pollen. The remaining 13 examined samples had poor pollen preservation, possibly owing to the interpreted marine depositional environment for many of the examined sites. Paleoclimate reconstruction from the 4 sites suggests sediments were deposited when mean annual precipitation was between 500 to 800 mm, and average summer temperature was between 9 and 14 °C. This is, on average, slightly cooler and wetter than present-day conditions at the sites. The absolute age of subglacial organic-bearing sediments at the four sites with preserved pollen is unknown. However, based on regional stratigraphic correlation, these sediments were most likely deposited during the last interglacial or penultimate interglacial.

Résumé

Au cours des campagnes sur le terrain de 2019 à 2021, 17 échantillons provenant de 11 sites de travail du sous-sol dans l'ouest des basses-terres de la baie d'Hudson ont été prélevés pour l'analyse du pollen. Lorsqu'ils sont correctement conservés, les registres de pollen contiennent des renseignements utiles pour reconstituer le climat passé pendant les périodes sans glace. Malheureusement, seuls 4 des 17 échantillons examinés contenaient du pollen adéquatement conservé. Les 13 autres échantillons examinés présentaient une mauvaise conservation du pollen, peut-être en raison de l'environnement de dépôt marin interprété pour un grand nombre des sites examinés. La reconstitution du paléoclimat à partir des 4 sites suggère que les sédiments ont été déposés lorsque les précipitations annuelles moyennes se situaient entre 500 et 800 mm et que la température estivale moyenne se situait entre 9 et 14 °C. En moyenne, ces conditions sont légèrement plus fraîches et plus humides que les conditions actuelles sur les sites. L'âge absolu des sédiments organiques du sous-sol sur les quatre sites où le pollen a été préservé est inconnu. Toutefois, sur la base de la corrélation stratigraphique régionale, ces sédiments ont très probablement été déposés au cours du dernier ou de l'avant-dernier interglaciaire.

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Introduction

A key region for reconstructing the history of North American glaciation is the Hudson Bay Lowland, which contains a rich stratigraphic record of glacial and non-glacial sediments. Various attempts have been made to date these sub till nonglacial deposits over time, through amino acid racemization in marine shells (Andrews et al., 1983; Nielsen et al., 1986; Thorleifson et al., 1992), radiocarbon dating (McDonald, 1969; Dredge et al., 1990; Dalton et al., 2016) and thermoluminescence or optical stimulated luminescence dating (Berger and Nielsen, 1991; Roy, 1998). These methods have met with mixed success, namely identifying ice-free conditions during some part of Marine Isotope Stage (MIS) 7 (243–191 ka, Lisiecki and Raymo, 2005; Allard et al., 2012; Hodder et al., 2023; Gauthier et al., 2024) and MIS 5 (130–71, Lisiecki and Raymo, 2005; Gao et al., 2020). Ice-free conditions during MIS 3 (57–29 ka, Lisiecki and Raymo, 2005) have also been proposed (Dalton et al., 2016; Dalton et al., 2019), but the feasibility of ice-free conditions during that time, along with the validity of the geochronological dataset, remains debated (Miller and Andrews, 2019; Kerr et al., 2021; Hodder et

al., 2023; Gauthier et al., *in press*). Regardless of specific timing, understanding paleoclimate in the Hudson Bay Lowland during previous non-glacial intervals has been undertaken on these sites for many decades (e.g., Terasmae and Hughes, 1960; Mott and DiLabio, 1990; Dredge et al., 1990; Dalton et al., 2017, 2018, 2022). We herein present palynological analysis on 17 samples from 11 sub till sites in the western Hudson Bay Lowlands that were collected in 2019–2021 (Figure 1; Table 1).

Methods

In the field, each section was first cleared of any present-day vegetation and colluvium. The stratigraphy of each site was thoroughly described and samples for pollen analysis were then taken at 5 cm or 10 cm intervals (see Table 1). Stratigraphic columns for each site investigated are provided in Appendix 1. A 1 cm³ subsample of each of the 17 pollen samples was then processed using standard palynological techniques (Faegri and Iversen, 1975) that have been adapted to cope with the sediment-rich samples from the Hudson Bay Lowland (Dalton et al., 2022). In brief, humic acids were digested using KOH and sediments were

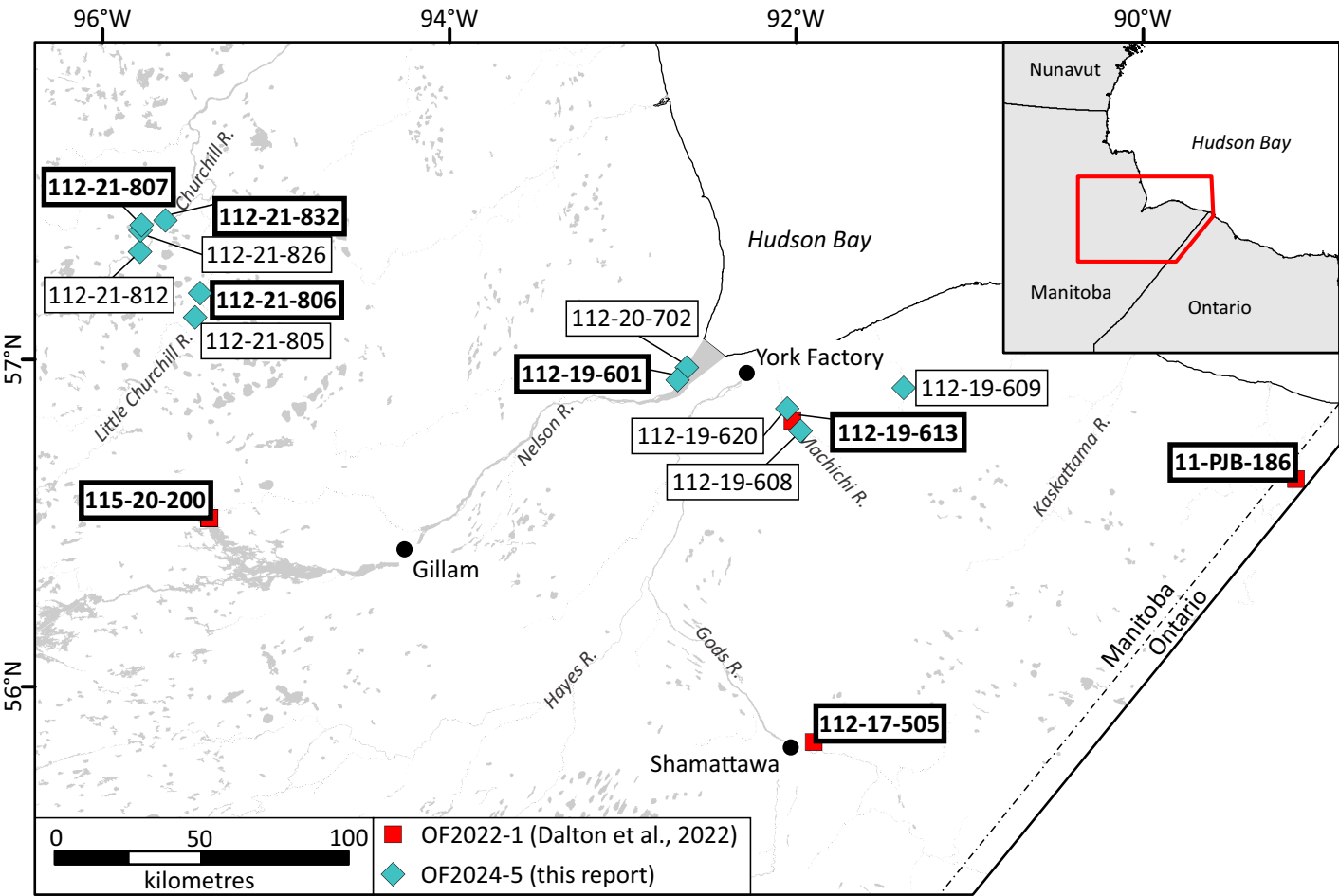


Figure 1: Location of sites in the western Hudson Bay Lowlands where sub till nonglacial sediments were investigated for pollen as part of this report (teal diamonds) and a previous report by the same authors (red squares; Dalton et al., 2022). Section labels bolded with a thicker black outline contain at least one sample sufficient for a paleo-climate reconstruction.

Table 1: Summary of samples processed for pollen from 11 sites in the western Hudson Bay Lowlands.

Section_ID	Latitude (DD)	Longitude (DD)	Sample_ID	Sample interval (m depth)	Sample medium	Are pollen data of sufficient quality for paleoclimate reconstruction?	Reconstructed Mean annual precipitation (mm)	Reconstructed average summer temperature (°C)		
112-19-601	56.971	-92.700	112-19-601-PM004	5.50–5.55	peat bed	✓ yes	515 ±169	11.7 ±1.8		
112-19-608	56.817	-92.005	112-19-608-D01	6.90–6.95	blue-grey clay	No pollen				
			112-19-608-D02	7.40–7.45	blue-grey clay	No pollen				
			112-19-608-E01	7.90–7.95	brick red silt	No. Low conc. and >10% broken.				
112-19-609	56.949	-91.427	112-19-609-PM006	2.35–2.40	laminated silt and fine-sand	No. Low conc.				
112-19-620	56.890	-92.085	112-19-620-C01	8.50–8.55	blue-grey clay	No. >10% broken.				
112-20-702	57.023	-92.637	112-20-702-F01	6.00–6.70	glaciomarine diamicton	No. Low conc. and >10% broken.				
112-21-805	57.150	-95.411	112-21-805-G01	13.00–13.80	silty fine-sand	No. >10% broken.				
112-21-806	57.229	-95.391	112-21-806-PM1	10.10–10.20	organic-rich sediment	✓ yes			771 ±169	9.0 ±1.8
112-21-807	57.434	-95.696	112-21-807-PM1	15.80–15.90	silt	✓ yes			508 ±169	12.1 ±1.8
			112-21-807-PM2	17.80–17.90	silt	No. Low conc. and >10% broken.				
			112-21-807-PM3	18.10–18.20	silt	No. >10% broken.				
112-21-812	57.346	-95.736	112-21-812-PM1	4.20–4.30	organic nodules	No. Low conc. and >10% broken.				
112-21-826	57.424	-95.719	112-21-826-PM1	16.70–18.40	detrital organics in sandy gravel	No. Low conc. and >10% broken.				
112-21-832	57.446	-95.596	112-21-832-PM1	34.80–34.90	fine sand	No. Low conc. and >10% broken.				
			112-21-832-PM2	36.00–36.10	silty fine-sand	✓ yes	800 ±169	14.3 ±1.8		
			112-21-832-PM3	36.20–36.25	bedded sand and clay	No. Low conc. and >10% broken.				

removed using HF. Sodium polytungstate was then used to separate any remaining sediment from the pollen residue (Zabenskie, 2006; Campbell et al., 2016) and a known quantity of ceramic palynospheres were added to each sample to estimate the pollen concentration (Kitaba and Nakagawa, 2017). Next, acetolysis and Safranin O was used to clarify and stain the pollen grains prior to being dehydrated, mixed with silicone oil and mounted onto slides.

Identification and enumeration of pollen grains took place using a compound microscope at 400x. Using the pollen key of McAndrews et al. (1973), the aim was to count at least 150 pollen grains on each slide. However, this was not achieved with many of the examined samples because of exceedingly low pollen concentrations (<5000 grain per cm³) and poor preservation (>10% broken). Such low concentration and poor preservation render any pollen-based inferences unreliable; therefore pollen enumeration was not continued at those intervals. All raw pollen data are available in Appendix 2.

Mean annual precipitation and average summer temperature (June, July and August) were reconstructed using the modern analogue technique (Overpeck et al., 1985) along with a calibration set of 4882 modern-day pollen sites spanning North America (Whitmore et al., 2005; Dalton et al., 2017). Sites from the modern pollen dataset were considered to be appropriate analogues if they had a squared chord distance dissimilarity of <0.15. Paleoclimate variables were constructed using the k=3 closest analogues and n=500 bootstrap iterations.

Results

Four of 17 sediment samples contain pollen of sufficient quality for paleoclimate reconstruction. Most of the samples with poor pollen preservation were from clay or silt deposits that were interpreted to have been deposited in a marine environment (Appendix 1). It was expected that these sediments might preserve trace amounts of pollen similar to what has been documented off the southern coast of Greenland (de Vernal and Hillaire-Marcel, 2008). However, this was not the case here.

The four samples with adequate pollen preservation were from sites 112-19-601, 112-21-806, 112-21-807 and 112-21-832 (Figure 1). These sites generally contained organic-bearing sediments, similar to other subfossil studies with adequate pollen preservation in the Hudson Bay Lowlands (Terasmae and Hughes, 1960; Mott and DiLabio, 1990; Dalton et al., 2017, 2022). As seen in Figure 2, the four samples contained pollen typical of a boreal forest and peatland environment, including a dominant arboreal component (*Picea*, *Pinus*, *Betula*, *Alnus*, *Salix*) along with wetland (*Cyperaceae*, *Sphagnum*) components. Using the modern analogue technique, there are numerous analogue sites in present-day North America (squared chord distance dissimilarity of <0.15; Figure 3) and the examined fossil pollen assemblages were most similar to pollen at present-day sites along the Canadian boreal forest, centered on the Hudson Bay Lowland (Figure 4). Quantitative paleoclimate reconstruction from the sediments suggests they were deposited when mean annual precipitation was between 500 to 800 mm, and average summer temperature was between 9 and 14 °C. This is, on average, slightly cooler and wetter than the present-day conditions at the sites, which are approximately 12.7°C and 482 mm respectively (Natural Resources Canada, 2015).

The absolute age of subfossil organic-bearing sediments at the four sites with preserved pollen is unknown. Sites 112-21-806, 112-21-807 and 112-21-832 are from the same interpreted stratigraphic unit in the Churchill–Little Churchill rivers. Based on the stratigraphic framework, they are interpreted to be older than the last interglacial period (Hodder et al., in prep.) At site 112-19-601 (Figure 1), near the mouth of the Nelson River, wood fragments from the same analyzed peat bed and a gravel below, both yielded non-finite radiocarbon ages (>55 ¹⁴C ka BP, UOC-10974, UOC-10975; Hodder et al., 2023). The stratigraphic framework there suggests these organic-bearing sorted sediments were likely deposited at some point during the last inter-

glacial period (MIS 5, 71–130 ka; Hodder et al., 2023). The new paleobotanical data support interglacial deposition, perhaps during a slightly cooler and wetter phase.

Discussion

Preserved pollen on nonglacial sediments at eight different sites in the Hudson Bay Lowland has been used to create paleo-climate reconstructions (Figure 1, Dalton et al., 2022 and herein). All examined pollen intervals are dominated by boreal and peatland taxa that are largely similar to Holocene pollen assemblages in the Hudson Bay Lowland (Farley-Gill, 1980; O’Reilly et al., 2014; Hargan et al., 2020). All sites contain indicators of wetland deposition. Together, these data suggest that ice-free intervals in the western Hudson Bay Lowland are largely similar to the Holocene, regardless of whether they are contemporaneous or represent different nonglacial intervals as currently interpreted based on stratigraphic and geochronological interpretations (Hodder et al., 2023, 2024; Gauthier et al., 2024). Our use of quantitative paleoenvironmental reconstructions reveals subtle differences in paleoclimate at some sites as compared to present-day, with variations between mean annual precipitation of ~430–920 mm, and average summer temperature of 9–15 °C.

Summary and conclusions

Seventeen samples from 11 subfossil sites in the western Hudson Bay Lowlands were evaluated. Four samples had adequate pollen preservation for paleoclimate reconstruction (sites 112-19-601, 112-21-806, 112-21-807 and 112-21-832), and the resulting work suggests they were deposited at the site during a period of slightly cooler and wetter conditions than present-day. All samples are dominated by boreal–peatland and wetland taxa that are largely similar to Holocene pollen assemblages in the Hudson Bay Lowland.

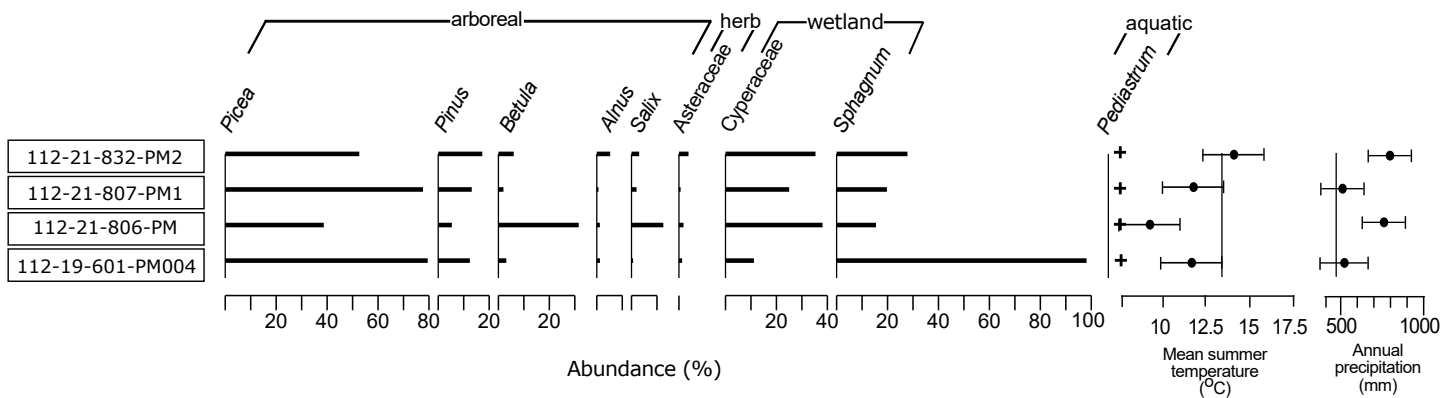


Figure 2: Pollen data along with paleoclimate reconstruction for the four samples with adequate pollen preservation. Vertical lines in the paleoclimate data plots represent present-day condition in the region, which are approximately 12.7°C and 482 mm, respectively (Natural Resources Canada, 2015).

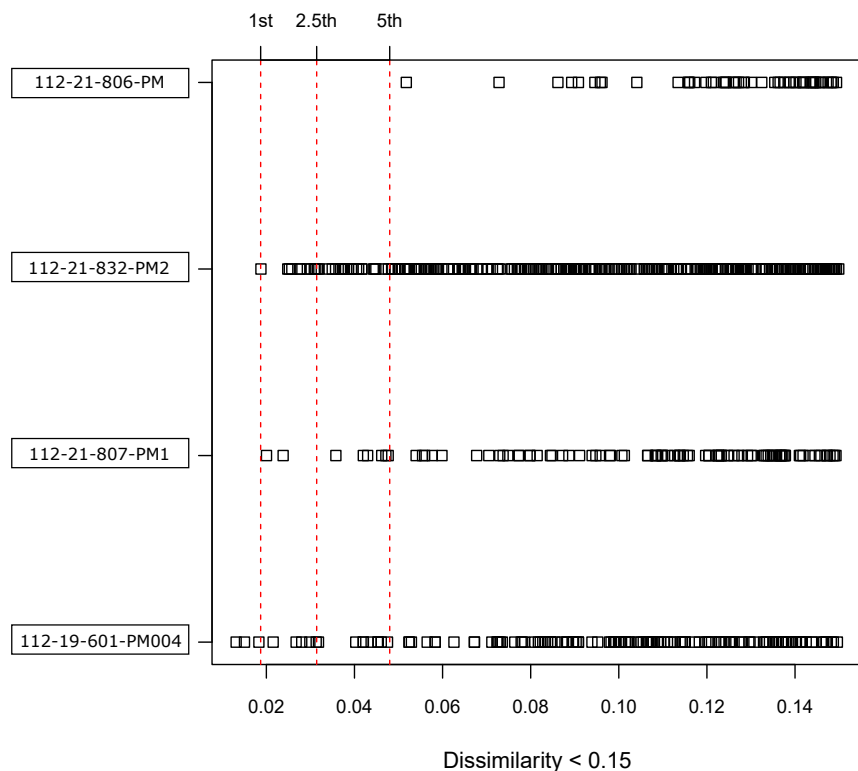


Figure 3: Results of the squared chord distance dissimilarity analysis for the 4 samples with adequate pollen preservation.

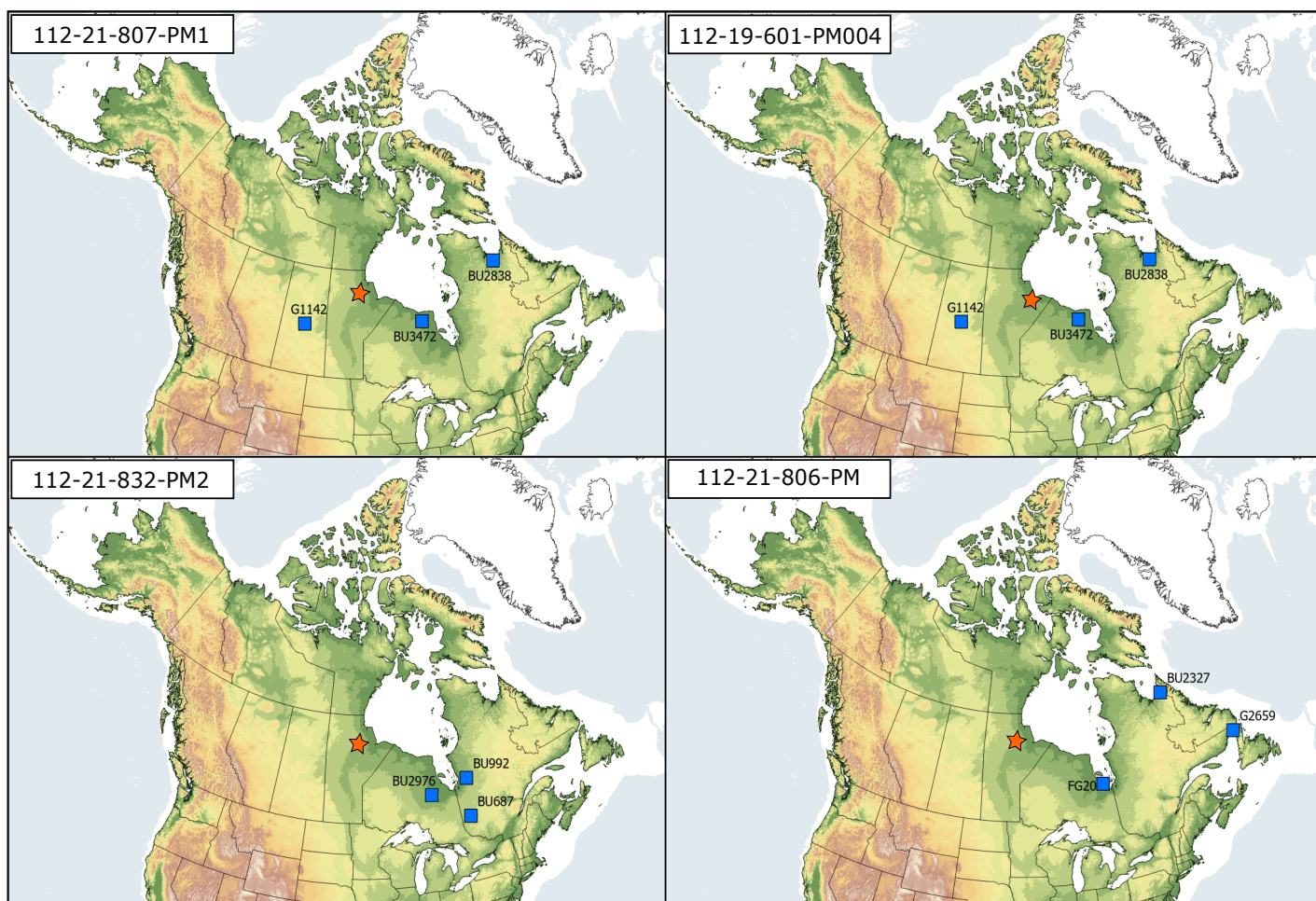


Figure 4: Map of North America showing the top three analogues (from the North American modern pollen database; Whitmore et al., 2005) for each pollen site examined in this report. Sites indicated by the orange star.

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