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The timing of peatland initiation in east-central British Columbia: a first look

By
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Abstract

A pilot study at the Aleza Lake Research Forest (ALRF) in east-central interior British Columbia (BC) examined the timing of peatland initiation using accelerator radiocarbon dating of peat deposits. At the ALRF, Sphagnum bogs occupy numerous closed depressions in an undulating plain underlain by impervious, fine-textured glacial lake sediments. Four adjacent Sphagnum bogs differed greatly in depth, with maximum peat thicknesses ranging from 70 to >550 cm. The oldest peat (9,177 ± 55 ^{14}C yr BP) occurred in a deposit less than 2 m thick, while a basal peat sample could not be obtained from the deepest basin examined. Two bogs with thinner deposits yielded younger basal peat ages (<4000 ^{14}C yr BP). More recent peatland initiation in shallower depressions may have been triggered by moister regional climates after the mid-Holocene. Future studies of peatland carbon stocks and peatland history in central BC will need to consider this potential climatic sensitivity and the spatial variability in peat thickness. Plant macrofossils and charcoal preserved in peat deposits could provide additional evidence for Holocene paleoenvironments in this region.

Introduction

Increasing concern over the climatic implications of rising atmospheric carbon dioxide concentrations has stimulated major efforts to estimate the magnitude and rates of change of forest carbon (C) stocks (Goodale et al., 2002). At the national level, modelling projects have greatly improved our understanding of the carbon budget of Canadian forests (Kurz and Apps, 1999.). But such efforts depend critically on the quality of their underlying empirical data, and complete inventories of forest carbon are scarce, particularly for belowground components such as soil organic C.

In east-central British Columbia, a recent study at the Aleza Lake Research Forest (ALRF; Figure 1) has collected and synthesized a large body of new data on major forest C stocks, including major components such as trees, understory vegetation, dead wood, and soils (Fredeen, 2006). This study was intentionally restricted to upland sites, as these were felt to be most sensitive to land management practices such as forest harvesting and silviculture. But the ALRF landscape (Figures 1, 2) contains numerous small wetlands and bogs, and although these occupy only 2% of the ALRF area (D. Janzen, personal communication), these

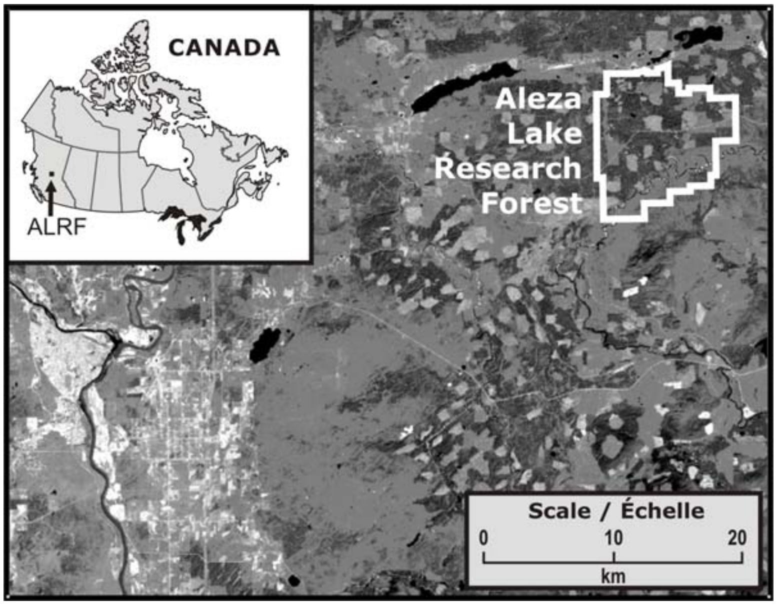

Figure 1* The Aleza Lake Research Forest (ALRF) lies at the eastern edge of British Columbia’s central interior plateau in the wet and cool subzone (SBSwk1) of the Sub-Boreal Spruce bioegeoclimatic zone. Upland forests are dominated by interior spruce (*Picea glauca x engelmannii)* and subalpine fir (*Abies lasiocarpa*). Mean annual precipitation at the ALRF is 930 mm (1/3 as snow) and the mean annual temperature is 3°C.

* Figure courtesy of D. Janzen, M.Sc. thesis.

features may be a significant C reservoir. For example, an inventory of soil carbon in Maine, USA, found that organic soils covered less than 5% of the state, but contained more than 1/3 of the total soil C (Davidson and Lefebvre, 1993).

Peatlands, and the organic deposits that comprise them, are also important archives of past environmental conditions (Charman, 2002). Peat accumulates when inputs of organic matter exceed its loss to decomposition. The changing balance between these two processes, as recorded in the thickness, composition, and age of peat deposits, can be a sensitive recorder of both regional climates and more local factors, such as changes in drainage patterns. In boreal and sub-boreal landscapes of central and northern BC, with a climate that is much drier than that of the coastal region, peat accumulation is restricted to topographic depressions where high water tables and anaerobic conditions suppress decomposition.

At the beginning of the Holocene (postglacial time), peat accumulation began in suitable locations exposed by the retreating ice sheets. The timing of peatland initiation in a given basin can be estimated by radiocarbon dating of the deepest peat. Using a database of 1680 such dates, a North American overview of this process was recently compiled by Gorham et al. (2007). Although peatland initiation appears to have peaked 7000-8000 years ago, it continues to the present day. Variations in the frequency of peatland initiations during postglacial history may reflect climatic fluctuations. For example, periods of drier climates would lead to fewer peatland initiations and/or reduced accumulation rates for existing peat deposits. Conversely, wetter climates would tend to favour peatland initiation and expansion.

For central and east-central BC, very little radiocarbon dating of peat deposits has been done. We lack even basic information on the thickness of peat deposits in this region of the province. Such information will enable estimation of the magnitude of peatland C reserves, and contribute to an understanding of the sensitivity of these deposits to environmental changes. This Note reports the results of a pilot study that attempts to remedy this knowledge gap by obtaining radiocarbon dates for peatland initiation at the ALRF, complementing the more extensive C inventory for upland forests. By concentrating on a small but representative area of the ALRF, our goal was to examine the local variability in peat thickness and basal peat ages.

Methods

We examined four adjacent bogs occupying closed basins in the undulating plain that comprises the southern portion of the ALRF (Figure 2). The underlying clay-rich sediments, deposited in a meltwater lake that temporarily occupied the Prince George area during deglaciation, are very impervious. The resulting strong contrasts in soil moisture regime across very small elevation differences

Figure 2. Peat sampling locations in the southern portion of the Aleza Lake Research Forest. Note the numerous closed depressions occupied by bogs with little or no tree cover.

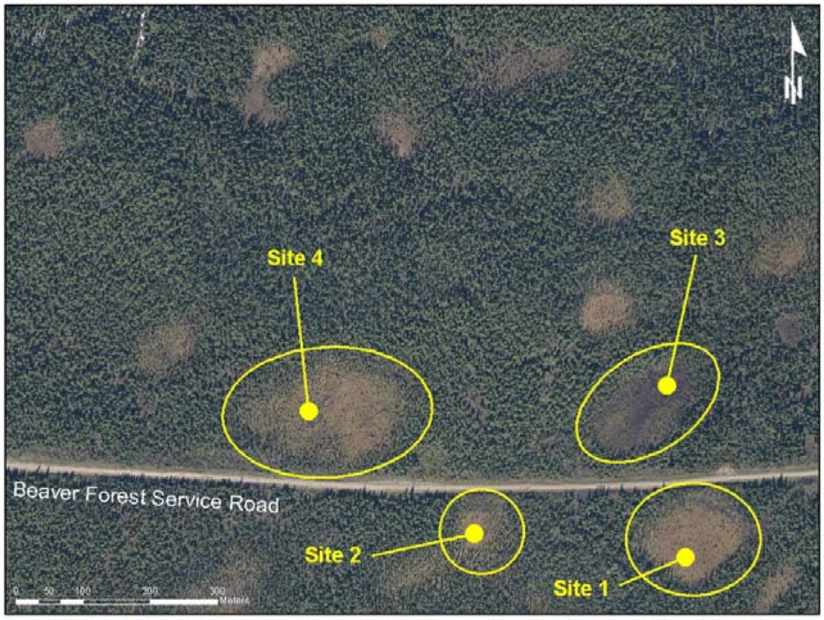

Figure 3. View of bog vegetation (Site 1 in Figure 2) at the Aleza Lake Research Forest.

(<10 m) create striking contrasts in vegetation, ranging from productive upland forests to bogs with only scattered, stunted trees. The bogs are dominated by Sphagnum moss, with abundant low shrubs such as Labrador tea (*Ledum groenlandicum*) and scattered black spruce (*Picea mariana*) and lodgepole pine (*Pinus contorta*) (Figure 3).

Using a peat auger (Figure 4), we probed systematically across the bogs to identify the thickest deposits, and recovered complete peat cores in 50 cm increments down to the underlying glacial lake sediments. Cores were stored in longitudinally split PVC pipe and kept frozen until sampled. The deepest recognizable peat material was collected from each core, and submitted for accelerator radiocarbon dating at the NSF-Arizona AMS Facility (University of Arizona, Tucson, Arizona, USA). Sample types were identified as either Sphagnum or basal peat based on visual recognition in the field. Further work would be needed to confirm the botanical origin of the deepest portions of the cores.

Figure 4. Extracted core showing transition between basal peat (R) and glacial lake sediments (L). The bluish-gray colour of the sediments indicates anaerobic (oxygen-poor) conditions.

Dates are reported in radiocarbon years before present (^{14}C yr BP), which by convention is fixed as AD 1950, and also as calibrated ages expressed in calendar years before present. Age in radiocarbon years is calculated from the abundance of ^{14}C in the sample and the known decay rate of this isotope (half-life of 5730 ± 40 years). Radiocarbon dates can be expressed in actual calendar years, but to do this requires a calibration process that allows for the fluctuating content of ^{14}C in the atmosphere. At different times, organic materials will have different initial abundances of this isotope. Calibration is done with computer programs that incorporate these fluctuations as measured for organic materials that have been dated by independent methods (e.g., ancient tree-rings). Because of these fluctuations, calibrated ages are not exact single numbers but contain built-in uncertainties, and are expressed as an age range with a certain level of probability. The calibrated ages (Table 1) were calculated with the CALIB program (Stuiver and Reimer, 1993; Reimer et al., 2004) and are stated as age ranges estimated at the 1 s (68%) and 2 s (95%) levels of probability.

Table 1. Radiocarbon dates and peat sampling locations, Aleza Lake Research Forest.

Sample[*]	**Lab No.**	**Material**	**^{14}C age BP**	**Calibrated age (calendar years BP): 1 σ and 2 σ ranges**	**Latitude, Longitude**
1-1-165	AA78463	basal peat	9,117 ± 55	10,220 – 10,374 10,193 – 10,478	54º 3’ 43.7” N, 122º 2’ 56.2” W
1-1-100	AA78464	sphagnum	8,929 ± 49	9,934 – 10,186 9,905 – 10,212	(same as above)
1-3-125	AA78465	basal peat	7,747 ± 51	8,458 – 8,585 8,419 – 8,602	54º 3’ 44.0” N, 122º 2’ 57.0” W
2-1-70	AA78466	basal peat	2,408 ± 39	2,352 – 2,486 2,345 – 2,698	54º 3’ 44.8” N, 122º 3’ 16.2” W
3-4-550	AA78467	sphagnum	8,001 ± 52	8,777 – 8,997 8,650 – 9,012	54º 3’ 50.0” N, 122º 3’ 17.0” W
4-1-70	AA78468	basal peat	3,990 ± 42	4,419 – 4,518 4,298 – 4,570	54º 3’ 50.1” N, 122º 3’ 25.7” W

[*] Sample codes indicate: bog site number (see Figure 2) – core number – depth in core (cm)

Results and Discussion

One unexpected finding of our field work was the remarkable range in peat thicknesses between the four bogs that we cored (Table 1). There were no obvious topographic or vegetation indicators that differed between the two shallowest bogs (sites 2 and 4: maximum depths of 70 cm) and the deepest (site 3: >550 cm deep). Presumably the deeper depressions originated as kettles created by stranding of ice blocks when the glacial meltwater lake drained. Because our coring equipment could not reach the underlying lake sediments at site 3, the initiation of peat accumulation in this basin must predate 8,000 ^{14}C years BP.

Site 1 contained thinner peat deposits (< 165 cm), and the oldest dates in this project (Table 1). Note that peat accumulation in core 1 at this site was initially rapid, with little difference in age between the 165 and 100 cm depths, followed by a much lower accumulation rate for the balance of the Holocene. Additional dating higher up in this core might reveal further temporal variations in peat accumulation rates. Approximately 10 m away (core 3), the peat was thinner (125 cm) and the basal date was approximately 1200 ^{14}C years younger, suggesting that peat accumulation initially began in the deepest point of the basin, then spread outward. In the two shallowest peat deposits (70 cm thick at sites 2 and 4), basal dates were considerably younger: 2,408 ± 39 and 3,990 ± 42 ^{14}C years BP.

This small sample must be interpreted cautiously, but these data do suggest patterns and hypotheses that would be worth examining in a larger study. First, it makes sense that older basal ages were obtained for thicker deposits occurring in deeper basins – these would be more likely than shallower basins to have been wet enough to favour peat accumulation throughout postglacial time. Second, initiation of the shallower and younger deposits may be a response to more recent climatic change. The current climate at the ALRF, with over 900 mm of annual precipitation, reflects its location on a steep precipitation gradient between the drier interior plateau to the west and the inland rainforests on the windward side of the Cariboo and Rocky Mountains to the east. Small shifts in this gradient toward moister climates might tip the balance toward peat-accumulating conditions in shallow depressions underlain by impervious sediments. Postglacial climate and vegetation changes in this region of BC remain poorly documented, but a provincial synthesis of paleoenvironmental evidence suggests that climates became cooler and perhaps moister in the 4,500-3,000 ^{14}C years BP period (Hebda, 1995), with subsequent glacial advances in the Rocky Mountains in the late Holocene (Osborn et al. 2001). If rates of peat accumulation in this region have fluctuated considerably in response to postglacial climatic changes, then a more complete inventory of this C reservoir must consider not only its current size but its climate sensitivity.

These preliminary observations represent only a small part of the wealth of paleoenvironmental information preserved in these peat deposits. Future investigations could include detailed reconstructions of past vegetation changes through identification of plant macrofossils, an approach that has been applied in adjacent regions (Bauer et al., 2003). We also observed numerous thin (<2 mm) charcoal bands in these cores, and such features can enable reconstruction of local fire history (Ohlson et al., 2006).

Conclusions

Based on a small pilot study involving four bogs at the Aleza Lake Research Forest, both peat thicknesses and the timing of peatland initiation show considerable local variation. Peat accumulation began later in the Holocene in shallow depressions, and initiation of these younger deposits may be climatic-related. If this is borne out by a larger study in this region, then the potential response of peatlands to future climatic changes will need to be considered in any evaluation of the fate of this C reservoir. Studies of plant macrofossils and charcoal preserved in peat deposits can contribute to our understanding of the postglacial environmental history of this poorly-studied region of the province.

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Further Readings or Resources

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