Driftcretions: A study of land growth from driftwood, Great Slave Lake, Canada

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Abstract

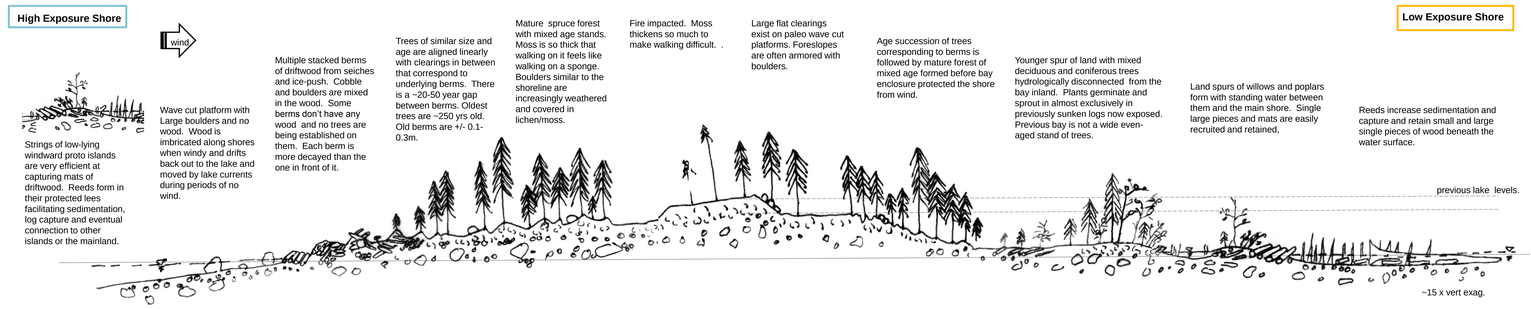
Islands and shorelines near the Slave River Delta on the Great Slave Lake, Northwest Territories, Canada, are enlarging over time directly due to accretion of large, successive parallel berms or mats of driftwood (driftcretions). This study describes wood accretion processes on the leeward and windward sides of islands and on the shores of protected bays. Large driftcretions are deposited episodically by ice, wind, and seiches (lake tsunamis). Accretion rates (e.g. 0.13 meters/year) were calculated by using tree rings from bands of even-aged stands of spruce parallel to shorelines. The Slave River provides 74% of the inflow to the Great Slave Lake and a large yearly wood flux (>3300 m^3/yr). The W.A.C. Bennett dam and nearby Peace Canyon dam are the only in stream obstructions in the Slave River catchment. Approximately 87% of the 6 x 10^5 km^2 basin is free flowing. Due to minimal development along river corridors, recruitment of trees within the basin is likely the same or very similar to what it was before settlement by Europeans. Thus, the processes described by this study may be a good proxy for shoreline dynamics in marine and freshwater water bodies near river deltas before widespread historical deforestation and wood removal along major rivers.

Basin Development

Un bassin grand comme trois fois la France

Map from Courrier International that shows dams, industry and development in the Mackenzie catchment (Wood, 2010). The Great Slave Lake is boxed. Existing dams are shown as black semi circles while proposed dams are in red.

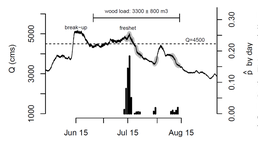
Idealized Cross Section based on observations and elevation transects from Paulette and Moose Deer Islands



Background

On Driftwood

Riverine Wood Input: Most wood comes from the Slave River, which contributes ~76% of the Inflow to the Great Slave Lake. Some wood is delivered every year with ice breakup and the spring freshet, but very large wood fluxes are episodic. Frequency and magnitude of these episodic events are currently being investigated as part of a larger project. Wood has been delivered continuously to the lake since the retreat of the Laurentide Ice Sheet and draining of Glacial Lake McConnell (ice marginal lake that combined the Great Slave Lake with Lake Athabasca and Great Bear Lake) ~8000 BP.

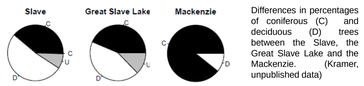


Plot of probability by day of seeing floating wood float past a timelapse camera on the Slave River, in relation to discharge. Shaded regions are sampled intervals. Total wood load for the 2013 season was estimated (Kramer, accepted ESPL). Below: In 2011 high flows exported an unmeasured wood flood to the lake

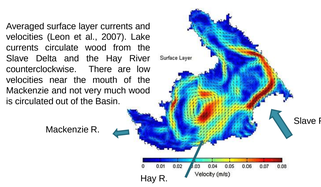
In 2011 high flows exported an unmeasured amount of wood flood to the lake that would far exceed the 3300 cubic meter estimate for the 2013 season

Vanderburgh and Smith (1988) were able to date the progradation of the Slave River from buried wood in deltaic sediments. The Slave Delta sediments filled a prior arm of the lake at a rate of 20.7 m/yr.

Riverine Wood Output: As evidenced from timelapse photography of outflow, lake currents, air photos and differences in surveyed logs, most logs do not drift downstream into the Mackenzie.



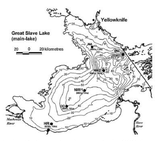
Differences in percentages of coniferous (C) and deciduous (D) trees between the Slave, the Great Slave Lake and the Mackenzie. (Kramer, unpublished data)



On Processes

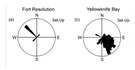
Ice: Floating lake ice during breakup can be pushed on shore by high river flows and wind (Lemay and Begin, 2012). It acts just like a bulldozer shoving driftwood and lake bottom boulders and cobbles into large shoreline berms. Break up occurs during May (Kang et al., 2012)

Climate and Anthropogenic Change: The Hydrology of Canada's North is expected to change radically in the next century (Rouse, et al., 2003). For this study, changes in timing and frequency of ice jam flooding and ice push will be particularly important.



Lake Bathymetry (Leon et al., 2007). Note the shallow south shore near the inlets to rivers draining sediment rich southern catchments.

Wind and Seiches: A seiche is a sharp lake level fluctuation generated by sustained winds or rapid barometric changes. Height of seiche is most dependent on wind duration, fetch distance across the lake and topography of lake bottom near shore (Gardner et al., 2006).



Rose Diagrams of seiche forming wind directions for the southeast shore (Fort Resolution) and the north shore (Yellowknife Bay) (Gardner et al., 2006)

Isostatic Rebound: Isostatic rebound of the Slave Delta following the drainage of glacial lake McConnell is estimated to be 12cm/km for a total of 48 m (Vanderburgh and Smith, 1988).

Acknowledgements

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Future Directions

- More thorough analysis of error in tree core measurements as related to disturbance versus establishment and height of core.
- Spatial Mapping of Wood distribution along lake margins from flight reconnaissance, satellite imagery and aerial photography
- Using tree cores to determine ice push disturbance history (Lemay and Begin, 2012)
- Mapping and dating paleo shorelines 1000 yr.BP to present using LiDAR
- Analyzing vegetation change using Multi-spectral Imagery
- Monitoring wood input and output from Timelapse Photography (Kramer, accepted for publication, ESPL)

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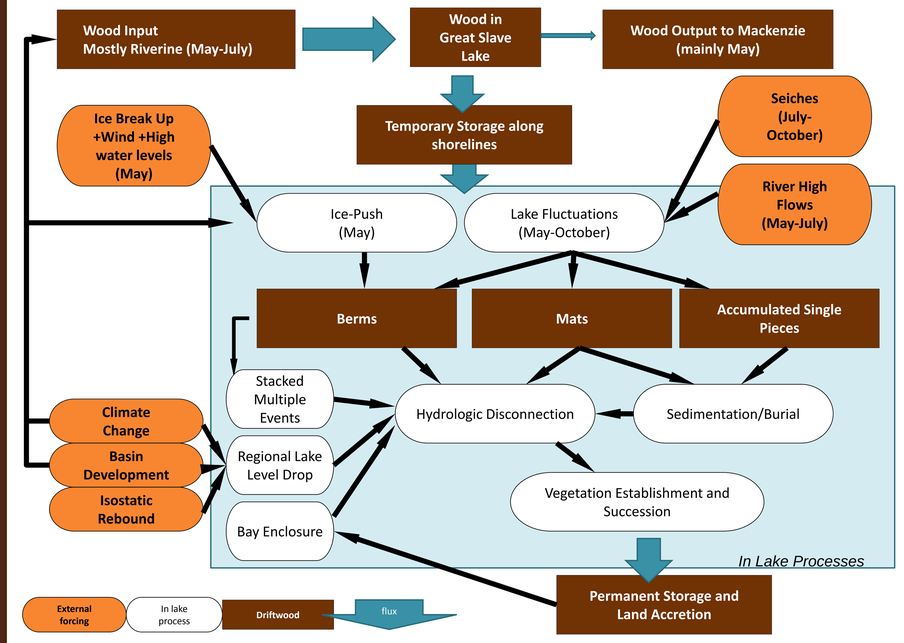
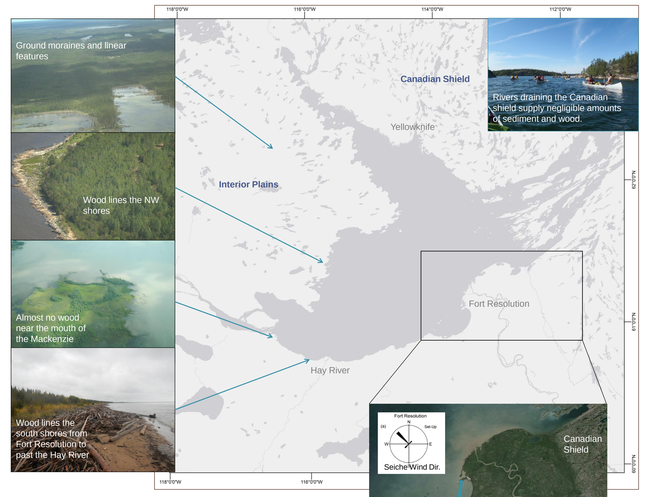
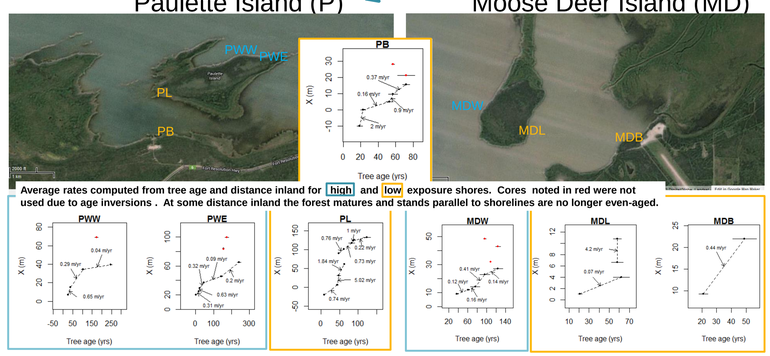


Wood in the Lake



Accretion Rates

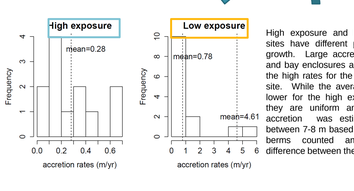


Average rates computed from tree age and distance inland for high and low exposure shores. Cores noted in red were not used due to age inversions . At some distance inland the forest matures and stands parallel to shorelines are no longer even-aged.

Additionally, from tree cores from windward stacked berms we can get rates /event

PWW
Inland 7-40m: 8m/event , 55yrs between events,
Inland 140m: 15 events = 830 yr. BP
PWE
Inland 25-65m: 8m/event, 45yrs between events
Inland 100m: 13 events = 590 yr. BP

MDW
From 9-26m: 7m/event, 22 yrs btwn events
Inland 200 m: 24 events = 530 yr. BP



High exposure and low exposure sites have different processes for growth. Large accretions of mats and bay enclosures are reflected in the high rates for the low exposure site. While the average rates are lower for the high exposure sites, they are uniform and per event accretion was estimated to be between 7-8 m based on number of berms counted and the age difference between them.

There appear to be three recent main regional events that deposited wood accretions, One between 1950-55 which may correspond to a seiche or a series of seiches, one between 1965-70, which may correspond to lake level drop from construction of W.A.C Bennett Dam (Gibson et al. 2006) 1970 . The last is between 1990-95 and in this preliminary analysis doesn't seem to correspond to ice or seiches. The 1974 appears to only correspond with windward accretion at both sites (with a 2-3 yr lag for tree establishment) and the 1997 high flow event only corresponds to sites on Paulette.