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Driftcretions: The legacy impacts of driftwood on shoreline morphology

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Key Points:

- Continued accretion of driftwood to shorelines alter morphology on large scales
- Driftwood-rich shores influence ecosystems, carbon capture, and erosional buffering
- Rates and volumes of accretion are nontrivial for basin wood and carbon budgets

Supporting Information:

- Supporting Information S1
- Data Set DS1
- Data Set DS2
- Data Set DS3
- Data Set DS4
- Data Set DS5

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Abstract This research demonstrates how vegetation interacts with physical processes to govern landscape development. We quantify and describe interactions among driftwood, sedimentation, and vegetation for Great Slave Lake, which is used as proxy for shoreline dynamics and landforms before deforestation and wood removal along major waterways. We introduce *driftcretion* to describe large, persistent concentrations of driftwood that interact with vegetation and sedimentation to influence shoreline evolution. We report the volume and distribution of driftwood along shorelines, the morphological impacts of driftwood delivery throughout the Holocene, and rates of driftwood accretion. Driftcretions facilitate the formation of complex, diverse morphologies that increase biological productivity and organic carbon capture and buffer against erosion. Driftcretions should be common on shorelines receiving a large wood supply and with processes which store wood permanently. We encourage others to work in these depositional zones to understand the physical and biological impacts of large wood export from river basins.

1. Introduction

Interactions among wood, sediment, and vegetation in rivers lead to major alterations of physical and ecological states [*Corenblit et al.*, 2011; *Dietrich and Perron*, 2006; *Hickin*, 1984]. A striking example is the coevolution of vascular plants with river meandering during the Carboniferous [*Gibling and Davies*, 2012]. Other examples include wood jams forcing multithread channels in low gradient mountain valleys [*Polvi and Wohl*, 2013], beaver dams controlling sedimentation and sustaining meadow wetlands [*Westbrook et al.*, 2011], in-stream wood on gravel bars initiating stable vegetated islands in anabranching rivers [*Gurnell and Petts*, 2002], large in-stream wood facilitating the expansion of alluvial old-growth forests on floodplains [*Collins et al.*, 2012], log rafts forcing avulsions and forming semistable, multithread distributary channels in deltas [*Phillips*, 2012], sunken logs in the deep ocean sustaining biological hotpots [*Knudsen*, 1970], and shoreline driftwood supplying a steady food source and creating habitat patchiness in coastal and mid-ocean ecosystems [*Maser et al.*, 1994].

Driftwood plays a major role in distributing water-borne nutrients and organic particulates, including carbon, into broader areas than would otherwise be reached [*Wipfli et al.*, 2007]. However, research investigating the long-term storage and decay of drift piles and their legacy impact on landforms, trophic cascades, and carbon cycling is limited. Global shorelines, especially in the temperate zone, are severely wood-impoverished relative to their condition prior to intensive human settlement [*Wohl*, 2014]. Thus, landforms along recently wood-impoverished river corridors and lakes may reflect past processes when driftwood was more abundant. Studying these processes and connecting vestige landscapes to driftwood are difficult in the absence of contemporary wood recruitment to shorelines.

A few large river catchments remain largely forested and unregulated. The Mackenzie River of Canada still exports large amounts of driftwood to the Arctic Ocean [*Eggertsson*, 1994]. We use Great Slave Lake as a natural, wood-rich laboratory to study the legacy of driftwood over time scales of $10^1 - 10^3$ years, including the morphological impacts of high wood loads along shorelines, rates of landscape change, and rates of fluvial driftwood export. This site provides a proxy for shoreline dynamics and landforms for marine and terrestrial depositional basins before widespread historical deforestation and wood removal along major waterways.

2. Methods

We used a combination of field and remote sensing techniques to investigate driftwood processes in Great Slave Lake. We circumnavigated the lake margin in a small aircraft, taking oblique air photos to record the distribution and amount of driftwood. Ground-based field visits were used to make observations, measure topography and driftwood, and core trees. Inferences about processes associated with high wood loads on shorelines on long temporal and large spatial scales were made using field observations, satellite imagery of lake margins in Google Earth, and the scientific literature. Expanded methods and observations, as well as derived data products, are included in the supporting information.

3. Driftcretions

We use driftcretion to refer to large concentrations of driftwood that promote sedimentation and interact with vegetation to influence shoreline morphology and evolution. Driftcretions are persistent rather than transitory landscape elements, and over time interact with vegetation and sediment to influence landscape form and function. Large log accumulations can become driftcretions if they become stabilized and vegetated until they are buried or decay in situ. We argue that driftcretions and their geomorphic impacts have three broad implications. Driftcretions (1) increase the biological productivity of shorelines by facilitating habitat patchiness and by providing a base food source to food webs, (2) provide shoreline protection from erosion by waves, and (3) facilitate the long-term capture and storage of carbon, both as buried wood and by increasing the amount of stable offshore standing water bodies which can capture carbon from the atmosphere [*Tranvik et al.*, 2009].

We classify driftcretions into three types: berms, mats, and a piecewise matrix. Berms are raised ridges of driftwood that form parallel to the shoreline when waves or ice push driftwood into linear piles. Mats are large, relatively flat, imbricated accumulations of driftwood composed of a mix of large and small pieces. A piecewise matrix is driftwood interspersed or layered in sediment. Figure 1 shows photographs of these three forms of driftcretions as well as shoreline morphologies facilitated by driftcretion. Figure 2 illustrates typical deposition of driftcretions along idealized transects for protected and exposed shorelines. These idealized transects are useful for understanding how driftcretions influence the appearance and evolution of the lakeshore.

In the Great Slave Lake, driftcretions impact progradation rates of shorelines and facilitate the infilling of the lake. This occurs through successive and continued accretion of drift piles and their subsequent decay and vegetation. Lake level change on timescales spanning days to thousands of years is the primary mechanism by which driftcretions form. Figure 3 conceptualizes relationships between time scales, amount of land accretion, driftcretion types, and shoreline morphologies for various types of lake level change. Driftwood is episodically delivered to the lake during ice breakup and river high flows and is distributed by surface currents. Driftwood becomes a driftcretion after it is disconnected from active lakeshore processes and hydraulic forces and subsequently vegetated. Disconnection occurs mechanically when lake level fluctuations from ice, storm waves, or large seiches (lake tsunamis [see *Gardner et al.*, 2006]), push or strand large piles of driftwood farther inland than can be reworked by lake processes before vegetation establishment. Disconnection can also occur when driftwood and shoreline grasses facilitate increased local sedimentation, eventually decreasing local lake depth enough that pioneer woody species like willow, alder, and poplar can grow. These pioneer species then act as nets which capture and retain large drift piles floated or pushed into them by waves and ice, further facilitating land progradation. In addition to episodic delivery and storage, some of the yearly flux of driftwood is buried in bottom sediments. If there is a regional drop in lake level, large expanses of driftwood-laden sediments become exposed and vegetated. Regional lake level may drop due to hydrologic alterations from human development of the river corridor, climate change, or isostatic rebound (around 0.2 cm/yr, [*Vanderburgh and Smith*, 1988]).

Additional descriptions, photos, and analyses of driftcretions that support our interpretations of process described above and synthesized in Figure 3 are in the supporting information. The next sections further discuss shoreline morphologies, distribution, and amount of stored driftwood, rates of driftwood accretion, and implications.

4. Shoreline Morphologies and Formative Mechanisms

Our observations suggest that on timescales from 10^1 to 10^2 years, berms, mats, and piecewise matrices work in concert and in succession to build large-scale landscape elements such as truncated channels, banded vegetation, islands and spits, scalloped shores, and captured bays (Figure 1, also supporting information). Morphological features associated with modern driftcretions (especially vegetative bands and enclosed bays) are still evident along previous shoreline locations up to the maximum extent of Glacial Lake McConnell,

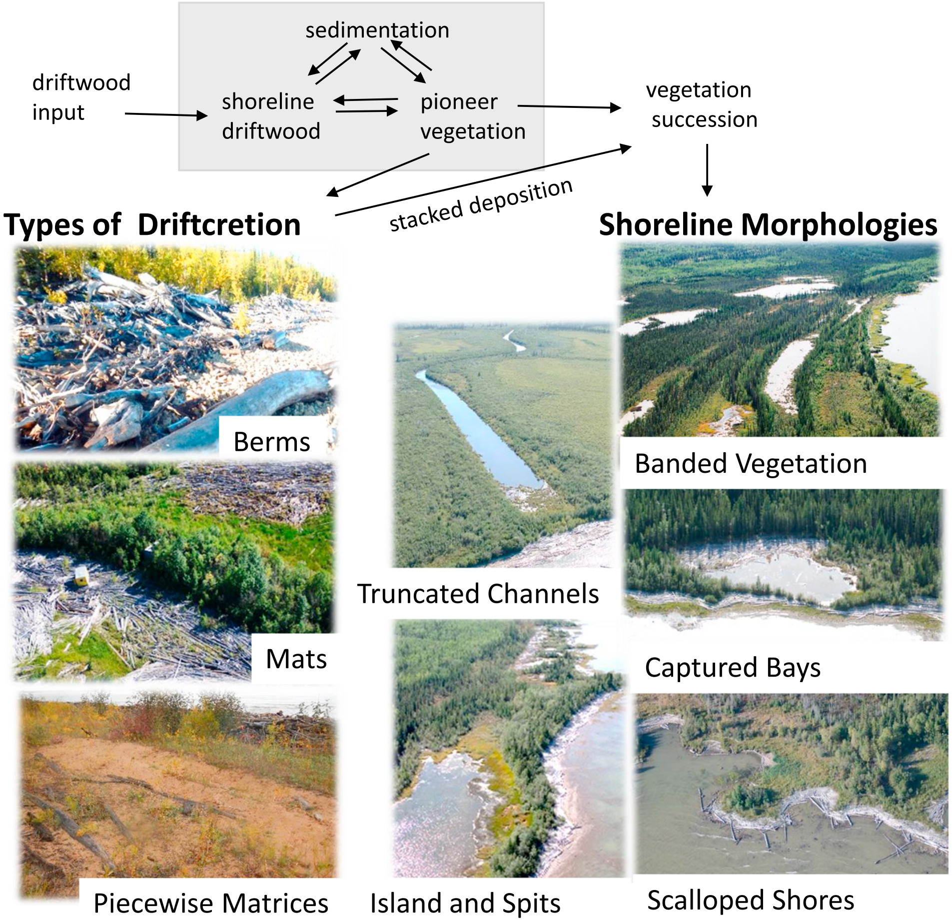

Figure 1. Conceptualization of processes which retain and facilitate driftwood to form driftcretions with examples of types and resulting shoreline morphologies. The three main impacts of driftcretions on shores are increased biological productivity and diversity due to increased habitat patchiness and food availability for trophic cascades; carbon capture in onshore water bodies and wetlands; and protection of shorelines from wave, ice, and flood disturbances.

about 70 km inland. Driftwood dates back 8000 years in Slave River deltaic deposits [*Vanderburgh and Smith*, 1988]; this suggests continued driftwood supply as lake level dropped throughout the Holocene from isostatic rebound and draining of the glacial lake [*Smith*, 1994]. Lowering of lake levels post glaciation set shoreline locations upon which driftcretions could form through mechanisms operating on shorter timescales.

4.1. Truncated Channels

Distributary channels can be cut off at their mouths by mats of driftwood originating, not from the channel but from drift along shorelines. If the influx of shoreline wood and associated sedimentation is greater than the ability of the distributary channel to keep its path to the lake clear, the wood effectively truncates the channel, forming a bridge across the mouth. This facilitates sedimentation and vegetation establishment. If more wood comes down the channel, it is jammed behind the bridge. Eventually, new shoreline builds outward in front of the channel and the channel starts to fill.

4.2. Banded Vegetation

Vegetation banding along shorelines reflects the episodic delivery of large amounts of driftwood. During a year of exceptional driftwood delivery (about every 20–50 years), large deposits of driftwood become permanently stored and converted into driftcretions linear to the shore. Vegetation preferentially establishes on decaying logs. Thus, sequential bands of vegetation parallel to the shore reflect not only the past shoreline locations but also the recurrence interval of large driftwood inputs.

4.3. Islands and Spits

Shallow shoals that become vegetated commonly create linear islands, spits, and peninsulas that protect the main shore from large waves and other disturbances. Behind the protection of these woody shoals, sedimen-

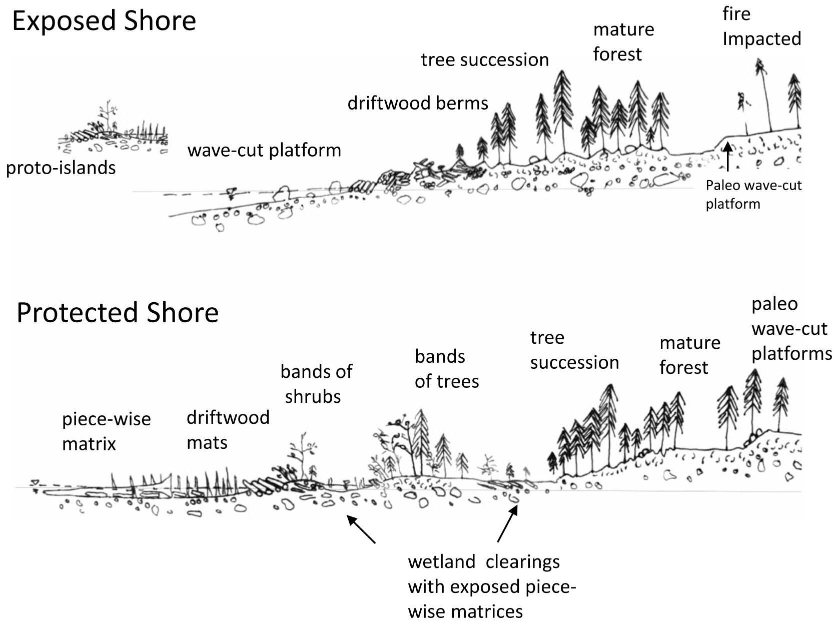

Figure 2. Two idealized cross sections which demonstrate the typical morphology of exposed and protected shorelines and relation to driftwood based on field observations and topographic surveys. Topography drawn with 15X vertical exaggeration. Vegetation is not to scale. Cross sections are approximately 200 m in length. Note the tree succession on topographic berms on the protected shoreline. Berms only form on high-exposure shores, so the presence of this sequence reflects past conditions when the shore was more heavily exposed. This occurred before vegetation established on the mats and piecewise matrices in front of the berms. This pattern demonstrates how the growth of islands and spits protect shorelines and facilitates rapid sedimentation.

tation, capture of smaller floating wood and pulp, and accumulation of piecewise matrices occur at increased rates. On shores with extensive land spurs and islands, the amount of shoreline (distance of land in contact with the main body of the lake) is increased by an average 2.7 times. In one location, the amount of shoreline increased by a factor of 8.

4.4. Scalloped Shores

Scalloped or crescent shores are a common geomorphic feature that typically develop on sandy beaches exposed to swash and backwash of waves. On Great Slave Lake, scalloped shores are coincident with high driftwood loads and are most pronounced on sandy and cobble shores perpendicular to wind direction. The presence of abundant driftwood makes scalloping more pronounced by anchoring projecting points and facilitating deposition in the embayments. The average sinuosity of scalloped shores is 1.5 m/m. These shorelines have increased potential for biological productivity due to the increased length of land-water interface.

4.5. Captured Bays

When scalloped shorelines and spits expand, they can enclose shoreline embayments. In regions with many bay enclosures, a mottled offshore landscape of standing water bodies and clearings is created that resembles a karst landscape with a high density of sinkholes or a glaciated landscape with kettle topography. We have observed these features in various stages of formation along the shoreline and near paleoshorelines, linking them to shoreline, rather than glacial or karst, processes. The topographic expression of captured bays is typically smaller than both karst and kettles, but appears similar in aerial photographs.

5. Amount and Distribution of Driftwood

Based on an analysis of stratified random sampling of oblique aerial photos from imagery covering the circumference of the lake, the average visible surface area of wood in mats or berms per meter of linear shoreline distance is 0.20–13 m^2/m for eleven shoreline regions (Figure 4). Wood-rich shorelines average 10–13 m^2/m of wood, but as much as 50 m^2/m of wood can be present locally (see supporting information for methods and calculations). Mats are present along all shoreline regions, but berms are only present along steeper shorelines

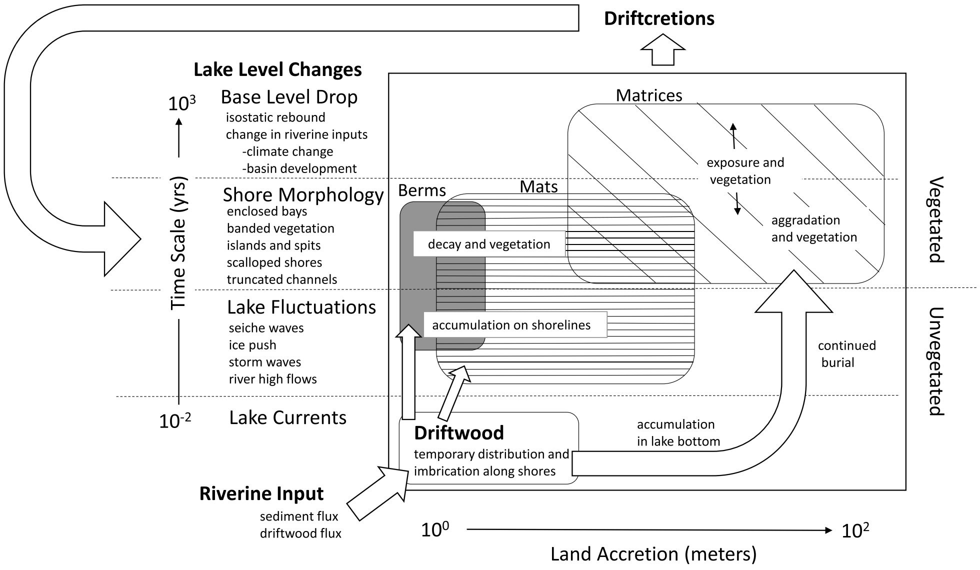

Figure 3. Conceptualization of driftcretion formation driven by changes in lake level at local and regional scales and on short and long timescales. The *x* axis denotes increasing widths of accreted wood and the *y* axis denotes increasing time scales for driftcretion formation. Starting in the lower right, driftwood enters the lake as yearly and large episodic fluxes and is then distributed by lake currents and wind. Once in the lake, piles of driftwood can become driftcretions through disconnection from active lake processes by the mechanisms of lake level change listed on the *y* axis, which operate generally at the timescales in which they are listed. The shaded boxes show the approximate formation time and size for each type of driftcretion. Over time, driftcretions vegetate and feed back into creation of shoreline morphologies which enable continued trapping and formation of new driftcretions, mainly by facilitating sedimentation, creation of irregular shorelines, and bay capture. Lake fluctuations float wood mats into new shallow shoreline areas, buried matrices are uncovered, and new berms are pushed on top of old berms.

that are approximately perpendicular to the predominant wind direction. Visible individual wood pieces were included in the total area estimation, but form less than 2% of the total area calculated. Piecewise matrices are not visible on photographs and were not included in the analysis.

The largest amount of wood accumulates on the southern shore due to proximity of major wood-supplying tributaries (Slave and Hay Rivers) and perpendicular orientation to wind. Negligible amounts of wood are supplied by northern and eastern tributaries because these areas either drain channels that flow through Canadian Shield bedrock or small basins of very low relief with disconnected, lake-rich channel networks that retain wood. Surface currents distribute wood entering from the major wood-supplying southern tributaries to the northern shore. Northern shorelines with the most wood are either perpendicular to wind direction and/or parallel with stronger currents. The eastern shorelines do not accumulate wood due to high-relief, rocky shorelines (supporting information). Surface currents bypass the lake outlet to the Mackenzie River, where almost no wood is found. Great Slave Lake is a wood sink and does not source appreciable amounts of wood to the Mackenzie River, as corroborated by time-lapse photography of the Mackenzie River at Fort Providence and local knowledge.

We estimate the total surface area of visible wood stored along the lake margins to be $4.6 \times 10^6 \pm 0.7 \times 10^6$ m^2 (see supporting information for calculations). Estimating volumes for drift piles can be imprecise due to large uncertainties and variances in the fraction of wood in jams and heights of jams. Thus, we report wood volumes and mass of carbon as a reasonable range rather than a bounded estimate. If we use conservative ranges of values for average height (0.5–1.5 m), fraction of wood (0.20–0.80), fraction of carbon (0.5) [*Lamlom and Savidge*, 2003], and density of wood (450 kg C m^{-3}), then the average volume per shoreline distance is on the order of 10^{-1} to 10^0 m^3/m and the average mass carbon per shoreline distance is on the order of 10^2 to 10^3 Mg C/m. These estimates are minima because the buried wood in piecewise matrices was not included. Based on tree cores and field observations, driftcretions become vegetated and unrecognizable by air after about 50 years (see supporting information). Thus, volume and mass estimates reflect only a half century of accumulation.

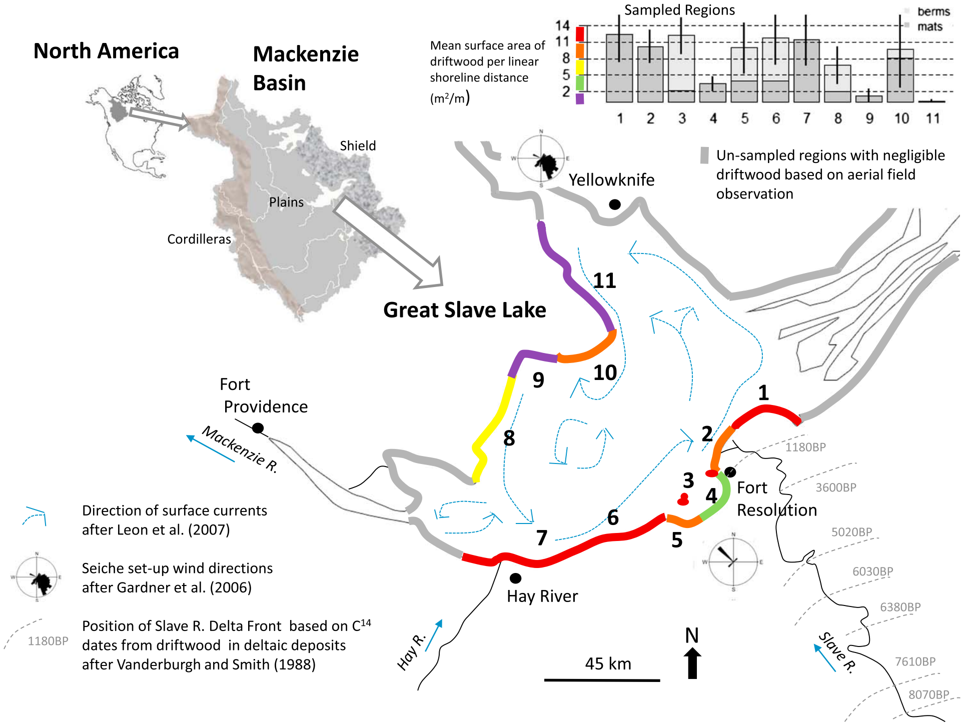

Figure 4. Driftcretion distribution around the lake. The colored bars shows high to low driftcretion volumes stored along lake margins based on estimated driftcretion area divided by shoreline length as displayed in the bar graph in the upper right. Numbers in bar graph relate to numbers drawn on the map. Seiche rose diagrams [*Gardner et al.*, 2006], lake surface currents [*León et al.*, 2007], and Slave River delta progradation positions [*Vanderburgh and Smith*, 1988] were adapted from previous literature.

6. Driftwood Depositional Rates

There is currently much interest in quantifying (1) rates of landscape change due to biotic-physical interactions [*Dietrich and Perron*, 2006; *Reinhardt et al.*, 2010], (2) in-stream wood budgets [*Benda and Sias*, 2003; *Boivin et al.*, 2015; *Schenk et al.*, 2014], and 3) the amount of carbon, as wood, recruited and exported from river networks to the oceans [*West et al.*, 2011; *Eglinton*, 2008]. In most field areas, calculation of only one or two of these metrics is possible due to the episodic and transitory nature of wood movement in channels and/or the depletion of wood from human activities. Great Slave Lake is unique in preserving a long record of transport volumes for discrete events.

Wood input into the lake today is similar to that in the historic past due to minimal development of the 6.8×10^6 km^2 wood-contributing drainage basin. Flow regulation impacts only around 10% of this area and most of the riparian corridor remains intact. At this site, where driftwood decay is slow because it is frozen for the better part of a year, driftwood is recognizable as wood 100 years after deposition (based on tree cores and field observations, see supporting information). Vegetative bands record wood depositional events up to the typical age of old-growth white spruce, around 300 years [*Timoney and Robinson*, 1996]. Rates of export can be calculated by coring living trees growing from wood piles in various stages of decay and distances inland (see supporting information for details).

Table 1 summarizes and compares rates of land accretion, and wood storage, recruitment and transport metrics from this and other studies. Wood recruitment values over the basin are 1 – 2 orders of magnitude less than reported values for headwater channels, basins in Japan, and steep tropical catchments. This seems appropriate, because this study averages recruitment over an entire drainage in which large areas likely are not directly supplying wood to the channel. The average transport rates for this site are very similar to or slightly higher than rates reported in Japan and Québec. Wood delivered to oceans from tropical storms may deliver more wood than an average wood transport event on the Slave River.

Table 1. Summary of Landscape Metrics, Storage, Recruitment, and Transport of Driftwood

	This Study	Other Study
Landscape Metrics		
Accretion per event	berms and mats: 4–10 m/event, matrices: 14–23 m/event	
Accretion per year	berms and mats: 0.1–0.4 m/yr, matrices: 0.6–1.4 m/yr	
Event recurrence	20–40 years	
Storage Metrics		
Time period (t)	50 years	
Events (n)	2–3 events	
Shore distance (X)	6×10^5 m	
Area (A)	$4.6 \times 10^6 \pm 0.7 \times 10^6$ m^2	
Volume (V)	10^5–10^6 m^3	
Carbon (C)	10^8–10^9 Kg C	
Recruitment Metrics		
Drainage area (DA)[a]	6.8×10^5 km^2	
Stream length (L)[a]	1.7×10^5 km (> third order)	
C/DA/n	10^1–10^3 Kg C/km^2	2.4×10^4 Kg C/km^2 as wood, vegetation, and soil from the Rio Chagres Panama during a tropical storm [*Wohl*, 2013]
$V/L/t$	10^{-4}–10^{-3} m^3/km/yr	0.2–5.1×10^{-1} m^3/km/yr [*King et al.*, 2013] upland headwater streams in British Columbia.
C/DA/t	10^1–10^2 Kg C/km/yr	82–5168 Kg C/km^2/yr from reservoir storage of wood from drainages of varying sizes in Japan [*Seo et al.*, 2012].
Transport Metrics		
C/n	10^5–10^6 Kg C/event	3.8–8.4×10^9 Kg C as wood soil and vegetation delivered to oceans from coarse wood during a tropical storm that triggered landslides in Taiwan [*West et al.*, 2011].
V/t	10^3–10^5 m^3/yr	1.93×10^3 m^3/yr based on 25,000 m^3 of wood trapped as rafts in the Saint-Jean River, Gaspé (Québec, Canada) over 50 years from 1963 to 2013 [*Boivin et al.*, 2015]
C/t	10^6–10^7 Kg C/yr	10^5–10^9 Kg C/yr measured from wood removed from reservoirs in Japan [*Seo et al.*, 2008]

[a] Wood-contributing drainage area and stream length. Sections of basin on the Canadian Shield that do not contribute driftwood were not included.

We used the distribution of germination ages derived from a tree ring analysis of cores to compare driftcretion deposition rates to rates of driving processes such as ice push, river discharge, and seiches (Figure 5). More of the trees germinated after 1950, especially on mats and matrices. This bias toward more recent events occurs because older mats and exposed matrices are located farther inland than the length of sampling transects and, unlike berms, decayed mats and fully vegetated mats and matrices lack topographic expression to distinguish discrete events.

Driftcretions accumulate episodically, generally coinciding with or lagging years of high river flows (Figure 5). This pattern is expected because high flows deliver a supply of wood that can later be pushed into berms. Large ice push events occur along exposed shores during years of high spring river flows simultaneous with lake ice off [*Bégin*, 2000; *Philip*, 1990]. Large seiche events typically occur in the late summer [*Gardner et al.*, 2006]. Mat deposition is more closely tied to the timing of high wood delivery than is formation of berms because berm formation may not coincide directly with high flow but rather large ice or seiche events. This lag between high flow and berm germination is apparent for the 1974 and 1990 peak flows (Figure 5). Spruce germination around 1950 probably correlates with unrecorded high flows in the late 1940s or with a period of multiple large seiches during 1930–1950. Development of an ice push event chronology using ice-scar chronologies on lakeshore trees and shrubs, as done for large northern lakes in Québec [*Bégin*, 2000; *Lemay and Bégin*, 2012], would greatly augment understanding of relationships among flow, ice push, and berm formation.

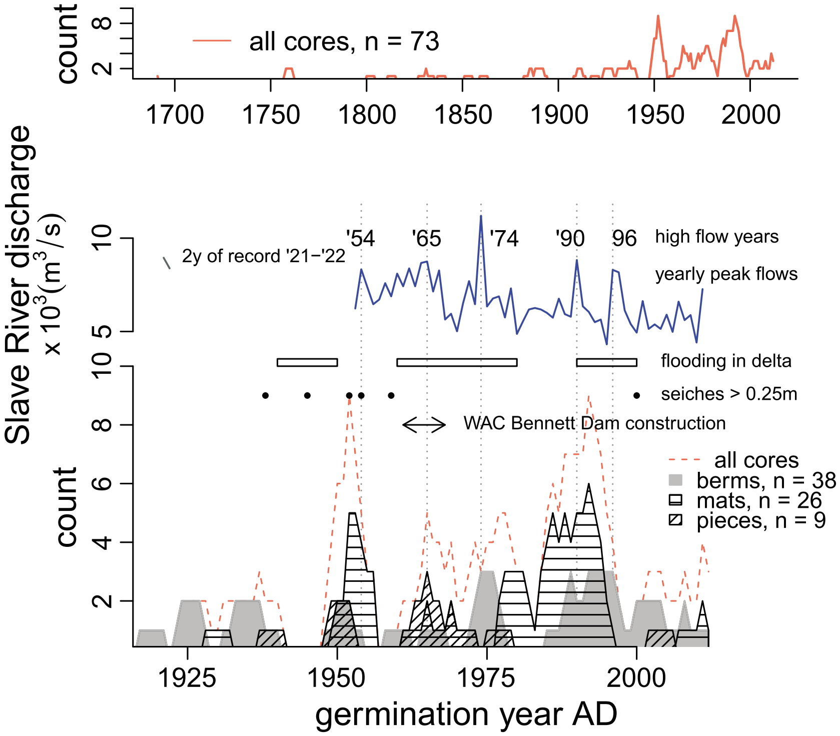

Figure 5. Counts of white spruce germination year for living trees growing on driftcretions. All cores are shown in the top graph. The bottom graph is a detail of the past 100 years and highlights relationships between germination year, peak yearly river flow (Water Survey Canada, Slave River at Fort Fitzgerald gauge 7NB001), flooding of delta lakes [*Brock et al.*, 2010], large seiche events [*Gardner et al.*, 2006], and construction of the W.A.C. Bennett Dam in the headwaters. Germination year was smoothed using a 5 year window in order to portray uncertainty.

Large-scale wood export is episodic and associated with peak river flows that follow periods of low flows during which driftwood accumulates along river corridors. On the Slave River, a very high peak flow in 1990 followed 16 years of lower flows (Figure 5). Germination on driftcretions peaked a few years after 1990, especially on mats. The lack of germination on driftcretions following the subsequent 1996 event may reflect the fact that the 1990 flow had already cleared much of the standing stock of wood on river banks and much less wood was delivered in 1996. In midsummer 2011, very large amounts of wood were delivered to the lake with high, but not extreme, flows just above 7000 m^{3}s^{-1}. During our 2013 and 2014 sampling, new spruce had not yet germinated on the newly deposited driftcretions from 2011. This suggests at least a 3 year lag between driftcretion deposition and vegetation establishment. For Great Slave Lake, summer lake levels declined after construction of the W.A.C Bennet dam in the headwaters of the catchment $>1 \times 10^3$ km upstream [*Gibson et al.*, 2006]. The high density of germination on piecewise matrices coincident and following dam construction likely reflects vegetation establishment on newly exposed sunken wood (Figure 5).

7. Implications

A complex mosaic of habitats and sinuous shorelines exists along Great Slave Lake because of the length of time over which abundant driftwood has been supplied to the lake. Enclosed bays, land spurs, and wind-protected shores support large expanses of marsh that trap additional driftwood and sediment and provide valuable habitat for fish, migratory birds, and mammals. Offshore standing water bodies resulting from bay capture and channel truncation are important sites of carbon capture [*Tranvik et al.*, 2009; *Mongeon*, 2008]. Driftcretions protect shorelines from wave and ice processes and facilitate backshore sedimentation, which promotes shoreline progradation into the lake.

Driftcretions and their resulting landforms should be common on shorelines which receive a large wood supply and store wood permanently. Using Google Earth, we found evidence of driftcretion in (1) protected embayments along marine coastlines (e.g., Montague Island south of Anchorage, Alaska), (2) portions of freshwater lakes at high latitudes (e.g., Great Bear Lake, Ozero Keta, and Ozero Khantayskoye in Siberia east of the Yenisei River, Lake Ladoga, and Lake Onega in the Karelian portion of Russia), (3) portions of reservoirs (e.g., Vilyuyskoye Vodokhranilishsche in the Sakha region of Russia), and (4) marine deltas (e.g., Yukon River delta). Abundant preserved wood accumulations in Pliocene sediments along the Arctic coast were deposited when global climate was 2–3° warmer and boreal forests grew within 10° latitude of the North Pole [*Davies et al.*, 2014]. These deposits suggest that as modern tree lines migrate northward, driftcretions may increase along Arctic shores barring intensive deforestation of river corridors in Siberia and northern Canada or loss of boreal forest during fires.

Although driftcretions may be more common in the boreal, there is no reason to assume that they are limited to cold, ice-dominated forested regions because berms can form not only through ice push but from strong waves, and because piecewise matrices and mats do not depend on ice processes. Descriptions strikingly similar to driftcretions were reported on high-energy coastal shores of Graham Island, British Columbia, where they form an important component of the beach-dune system that facilitates vegetation, impacts shoreline morphology, and limits erosion [*Walker and Barrie*, 2006]. Steep shoreline topography, removal of wood by humans, no substantial point source of wood, and locations above tree line limit driftcretion elsewhere.

The Arctic coast is now recognized as being at risk of erosion due to increased wave action, melting permafrost, and rising sea levels [*Forbes*, 2011]. If river basins draining to the Arctic are extensively developed for hydropower and/or old-growth forests along riparian corridors disappear to land use change, driftwood supply will drastically decrease. Our study suggests that if driftwood supply to shorelines decreases, Arctic coasts may lose buffering capacity offered by driftwood and related landforms, exacerbating coastal erosion.

Most in-stream wood research has focused on zones of wood production (mostly headwater channels) or wood transfer rather than zones of wood deposition. This study demonstrates that driftwood in depositional zones can profoundly impact the landscape as well as record long histories of wood export. We encourage others to investigate these landscapes. Of particular interest is understanding how driftwood-based landscapes are utilized by biota and how depletion of wood from river corridors by humans reduces ecosystem functions in formerly wood-rich depositional basins.

Acknowledgments
Data can be accessed at the Colorado State University Data Repository (http://digitool.library.colostate.edu/R/?func=collections&collection_id=5307). This study was supported by National Geographic Research CRE grant 9183-12 by the Committee for Research and Exploration, Geological Society of America Graduate Grants and the Warner College of Natural Resources, Colorado State University. Special thanks to Dave Oleson of Hoarfroast River Huskies Ltd. and Sean Buckley of Great Slave Lake tours for field support. The authors thank Brett C. Eaton and Francesco Comiti for their helpful comments.

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