Mackenzie River Driftwood — A Dendrochronological Study

'OLAFUR EGGERTSSON[1]

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ABSTRACT. As part of a general study of arctic driftwood, 206 samples of driftwood logs from the Mackenzie delta area were analyzed by dendrochronological methods (tree-ring studies). The aim was to detect the origin of the wood. Three forest stands in the delta were also sampled, and tree-ring chronologies were constructed. The Mackenzie driftwood can be divided into four groups: 1) driftwood originating from the upper Mackenzie delta area with individual logs having up to 600 tree rings, 2) driftwood originating near the southern limit of the delta, 3) wood with relatively few tree rings with possible origin in the Liard River drainage area, and 4) driftwood samples not datable with any available chronologies.

Three driftwood samples from the coast of Greenland could be correlated with tree-ring chronologies from the Mackenzie delta area and another three were correlated with chronologies from Alaska. American driftwood has not been detected in collections from Svalbard and Iceland, although more than 200 samples have been analyzed from each area. This indicates that some American driftwood is transported from the Beaufort and Bering seas to the North Atlantic Ocean, probably via the western part of the East Greenland Current. This wood is deposited on the coast of Greenland. American driftwood probably does not reach the islands in the central and eastern North Atlantic.

Key words: Mackenzie River, driftwood, dendrochronology, Arctic Ocean, East Greenland Current, surface currents, drift ice, Canada, Alaska

RÉSUMÉ. Dans le cadre d'une étude générale du bois flotté dans l'Arctique, on a analysé 206 échantillons de billes de bois flotté provenant du delta du Mackenzie grâce à des méthodes dendrochronologiques (études des faisceaux de croissance de l'arbre). Le but était de déterminer l'origine du bois. On a aussi fait un échantillonnage de trois peuplements de forêts dans le delta et on en a établi la chronologie des faisceaux de croissance. On peut diviser le bois flotté du Mackenzie en quatre groupes : 1) le bois provenant de la partie amont du delta du Mackenzie, avec des billes possédant chacune jusqu'à 600 cernes concentriques, 2) le bois flotté provenant de la limite méridionale du delta, 3) le bois ayant relativement peu de cernes, provenant peut-être du bassin hydrographique de la rivière au Liard, et 4) des échantillons de bois flotté pour la datation desquels aucune chronologie n'était disponible.

On a pu corréler par dendrochronologie trois échantillons de bois flotté provenant de la côte du Groenland avec des échantillons provenant de la région du delta du Mackenzie, et trois autres avec des échantillons provenant de l'Alaska. Dans des collections provenant du Svalbard et d'Islande, on n'a pas détecté de bois flotté américain, bien qu'on ait analysé plus de 200 échantillons de chaque région. Cela révèle qu'une petite quantité de bois flotté américain est transporté de la mer de Beaufort et de la mer de Béring jusqu'à l'océan Atlantique nord, probablement par la partie occidentale du courant est-groenlandais. Ce bois est déposé sur la côte du Groenland. Le bois flotté américain n'atteint probablement pas les îles du centre et de l'est de l'Atlantique nord.

Mots clés : fleuve Mackenzie, bois flotté, dendrochronologie, océan Arctique, courant est-groenlandais, courant de surface, glace de dérive, Canada, Alaska

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INTRODUCTION

Driftwood occurs along many arctic shores. The amount of driftwood varies greatly, from only scattered logs to beaches completely covered with wood. Occasionally there are thick piles of logs along stretches of the coast. In dry areas, driftwood can be preserved for thousands of years (Eurola, 1971; Blake, 1972; Häggblom, 1982; Bartholin and Hjort, 1987), in many cases with the tree-ring pattern preserved. By applying dendrochronological methods it should be possible to track the origin of the wood and date it, if a circumpolar network of tree-ring master chronologies is available.

The driftwood originates in the circumpolar boreal forest regions that surround the Arctic. The rivers draining into the Arctic Ocean carry huge quantities of driftwood that derive either from living forests undercut by rivers or from logs that have come loose during timber floating. Much of this wood is caught in drifting ice transported by ocean currents and is eventually deposited along barren shores. Driftwood has been used for studying the isostatic rebound after the last glaciation and Holocene eustatic transgressions (Blake, 1972; Salvigsen, 1981; Häggblom, 1982).

In recent years, the possibility of applying dendrochronological methods to driftwood has been suggested by Parker *et al.* (1983), Bartholin and Hjort (1987), and Eggertsson (1992). The suggestion was inspired by the work of Giddings (1941, 1943, 1952), who proposed the mapping of Arctic Ocean currents by using the tree-ring dating method. However, his primary interest was to cross-date the various driftwood populations along the Bering Sea coast and the arctic coast of Alaska. At the same time he noted that the source of some driftwood can be determined. For example, driftwood logs found on the shores west of Point Hope on the north coast of Alaska had a tree-ring pattern restricted to the Yukon region in Alaska. They must therefore have drifted down the Yukon River into the Bering Sea and then north through the Bering Strait into the Arctic Ocean.

The Mackenzie River Driftwood Project

The Mackenzie River system (Fig. 1) carries huge quantities of driftwood into the Arctic Ocean, mainly during ice breakup at the beginning of June (Mackay, 1963). The trees originate from living forests that have been undercut by the rivers (Fig. 2). Some logs are subsequently and temporarily deposited on the riverbanks, whereas others are carried to the Arctic Ocean. Ocean currents and sea ice transport the wood and deposit it along the arctic shores. The driftwood can resist decay for a long time in the dry conditions of the Arctic.

[1]Department of Quaternary Geology, University of Lund, Tornavägen 13, 223 63 Lund, Sweden

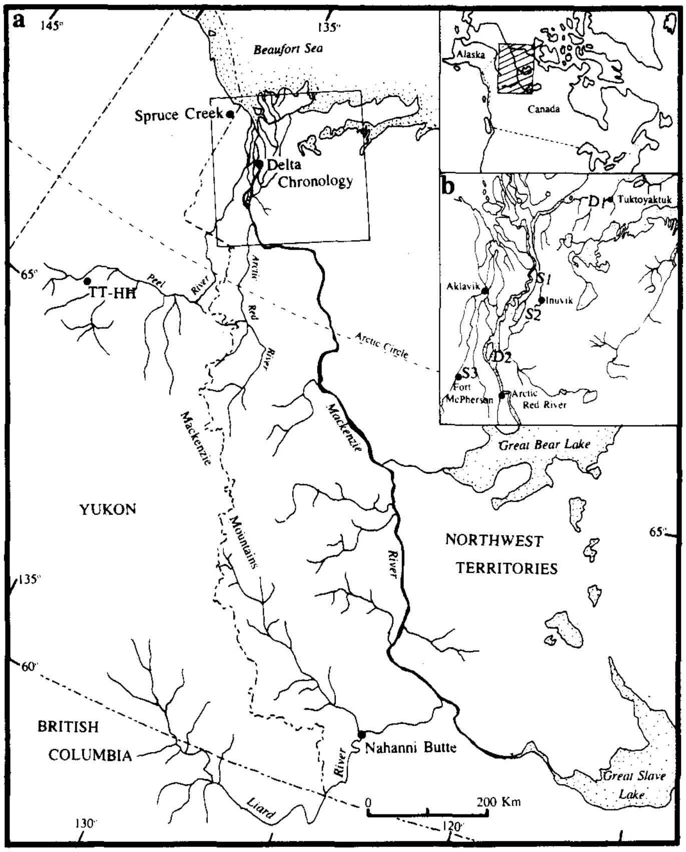

FIG. 1. a) Mackenzie River system and tree-ring chronology sites. b) Mackenzie delta. Driftwood sites: D1 = Peninsula Point, Tuktoyaktuk: D2 = Separation Point. Stand sites: S1 = north of Inuvik; S2 = south of Inuvik, S3 = Fort McPherson.

FIG. 2. Trees being undercut by the river in the delta region.

The aims of the present study are 1) to describe and identify the origin of the wood that presently drifts down the Mackenzie River into the Arctic Ocean and 2) to provide a dendrochronological master series for that wood, which then could be used to identify and date Mackenzie driftwood deposited on arctic shores elsewhere.

The Mackenzie River system was chosen as one reference river for an overall study of arctic driftwood because it is one of two main sources of American driftwood to the Arctic, the other being the Yukon River in Alaska (Eggertsson, 1992), which drains into the Bering Sea.

Kindle (1921) studied Mackenzie River driftwood and noticed that the great bulk of it came from the Liard River, which is the main tributary of the Mackenzie. He also noticed that spruce (*Picea*) and poplar (*Populus*) constituted the bulk of the wood.

The dendrochronology of the Mackenzie driftwood has not been studied before, but the work of Giddings (1941, 1952) on Yukon driftwood has been used to identify arctic driftwood of Alaskan origin (Eggertsson, 1992).

The Mackenzie River

The Mackenzie River and its tributaries drain an area of 1.84 million km^2. It is the second largest river system in North America, after the Mississippi. It is the longest river in Canada and one of the ten longest in the world, measuring 4220 km and flowing from Great Slave Lake in the south to the Beaufort Sea in the north, passing through boreal forest on its way to the arctic tundra. The main tributary is the Liard River, which originates in the Rocky Mountains of northern British Colombia and Yukon (Fig. 1).

Vegetation of the Mackenzie Delta

The northern part of the Mackenzie delta lies within the tundra zone, the southern part in boreal forest. The boundary zone between tundra and forested areas may be either sharp or transitional. In general the gradual sequence from south to north is: 1) continuous woodland, 2) open woodland, 3) patches of woodland and tundra with abundant willow (*Salix*) and ground birch (*Betula glandulosa*), 4) willow scrub (*Salix nigra*) and ground birch, 5) tundra with patches of willow scrub and ground birch, and 6) tundra (Mackay, 1963). The northern limit of the woodland-tundra (3) is placed at the inferred limit of spruce (*Picea*). Although isolated trees grow far beyond that limit, spruce is the dominant tree in the woodland-tundra but scattered balsam poplar (*Populus balsamifera*), tamarack (*Larix laricina*), and tree birches (*Betula papyrifera*) also occur. Spruce occurs mainly in the valleys and on slopes. The northernmost spruce in the delta grows today at 69°39′N, but during the Holocene climatic optimum (8500-5500 BP) spruce grew on the Tuktoyaktuk Peninsula 100 km farther north (Ritchie and Hare, 1971).

Open woodland (2) covers most of the area south of Inuvik. The predominant tree there is white spruce (*Picea glauca*), which grows in valleys and on the river terraces, often as isolated stands. Black spruce (*Picea mariana*) grows in some bogs. Tamarack grows on open rocky slopes and in depressions together with spruce. Poplars and tree birches are scattered. The area of continuous forest cover is relatively small, because it only occurs as narrow ribbons along the river channels and lakes (Mackay, 1963).

METHODS

During the summer of 1990, samples were collected from both living trees and driftwood. The living tree samples were taken with a Swedish increment corer. From the driftwood logs a disk was sawn about 1 m from the root or thick end using a chain saw, and the length of the logs and their distance from the river were measured.

Three stands of *Picea glauca* were sampled in the Mackenzie delta (Fig. 1). The first was from a well-drained area on an island in the modern delta about 6 km southwest of Inuvik (Fig. 1:S2). A total of 26 core samples were collected from 24 trees.

The second stand was on wetter ground about 8 km north of Inuvik, on the riverbanks of the East Channel (Fig. 1:S1). Here 34 cores were taken from 17 trees.

The third sampling locality was on the elevated Pleistocene delta 4 km east of Fort McPherson (Fig. 1:S3). Here 16 cores were taken from 8 young trees.

Driftwood samples were collected from the banks of the Mackenzie River (Fig. 3) between the village of Arctic Red River and Separation Point, just upstream of the delta (130 samples; Fig. 1:D2) and from the Beaufort Sea coast at Peninsula Point (Fig. 4), 10 km west of Tuktoyaktuk and at Tuktoyaktuk itself (160 samples; Fig. 1:D1).

Most of the 130 driftwood logs sampled at Separation Point still retained the root system and some bark. The main taxa were spruce (*Picea*) (80%) and poplar (*Populus*) (20%), although birches (*Betula*), alder (*Alnus*) and one tamarack (*Larix*) were also present. A total of 89 white spruce (*Picea glauca*) samples were measured and analyzed.

FIG. 3. The sampling locality at Separation Point (D2).

FIG. 4. Peninsula Point (D1). The driftwood can be seen on the beach.

The driftwood logs from the Tuktoyaktuk–Peninsula Point area were more eroded than those at Separation Point. Some still retained the root but many were broken and had no bark left. Of the samples, roughly 86% were spruce and 14% poplar. Some birches, alder, and tamarack were present but not sampled. From this area, 117 white spruce (*Picea glauca*) samples were measured and analyzed.

The tree rings in the driftwood samples were made more visible by cutting into the wood with a razor blade. Tree rings were measured in 1/100 mm units on an Aniol tree-ring measuring machine connected to a PC and analyzed using the CATRAS program (Aniol, 1983).

Two to four radii were measured in the driftwood samples and an average curve made for each tree/log. These tree curves were cross-correlated with each other using the CATRAS program's statistical technique (Aniol, 1983).

The CATRAS program calculates the percentage of agreement coefficients (sign test) for all positions of overlap between two chronologies, taking no account of the magnitudes of the year-to-year changes in ring width. When the program calculates the t-value, a simple standardization is carried out where each ring width is converted to a percentage of the mean in order to remove any trends from the basic data (Baillie and Pilcher, 1973).

Those tree curves showing high correlation values (t- and sign test values) were visually checked by comparing the graphical plots of the tree curves. The best fitted were used to build up mean chronologies from the driftwood samples. All chronologies were quality controlled by the COFECHA program (Holmes *et al.*, 1986).

Absolute chronologies were built up for the living tree sites, one chronology for each locality (Table 1). The statistical parameters are explained in Fritts (1976).

Additionally, chronologies from Giddings (1947), Cropper and Fritts (1981), Jacoby and Cook (1981) and Parker *et al.* (1973) proved useful for dating the driftwood tree curves and chronologies (Table 2).

The Greenland driftwood tree curves were standardized with a negative exponential function to smooth the growth trends in width values (Holmes *et al.*, 1986).

RESULTS

The *Picea* samples of the Mackenzie driftwood are divided into four groups based on possible origin and correlation with master chronologies.

The first group consists of long-living trees from the Tuktoyaktuk–Peninsula Point driftwood collection (Fig. 1:D1).

TABLE 1. Statistics of the mean tree-ring curves from living *Picea glauca* in the Mackenzie delta (sites shown on Fig. 1; terminology according to Fritts, 1976)

	N of Inuvik (S1)	S of Inuvik (S2)	Fort McPherson (S3)
Time span	1700 - 1989	1540 - 1989	1894 - 1989
Average mean sensitivity	0.180	0.197	0.143
Series intercorrelation	0.580	0.598	0.420
Autocorrelation	0.766	0.720	0.768
Number of trees	17	21	8

TABLE 2. Tree-ring chronologies from the Mackenzie drainage area (sites shown on Fig. 1)

Site	Location	Time span	Reference
N of Inuvik (S1)	68°25'N - 133°48'W	1700 - 1989	This paper
S of Inuvik (S2)	68°18'N - 133°45'W	1540 - 1989	This paper
Fort McPherson (S3)	67°28'N - 134°47'W	1894 - 1989	This paper
Spruce Creek	68°38'N - 138°38'W	1570 - 1977	Cropper and Fritts, 1981
Delta chronology	68°00'N - 135°00'W	1700 - 1941	Giddings, 1947
TT-HH	65°20'N - 138°20'W	1459 - 1975	Jacoby and Cook, 1981
Nahanni Butte area	61°00'N - 124°00'W	1800 - 1971	Parker *et al.*, 1973

They have grown slowly, with an average tree-ring width as low as 0.22 mm and with up to 600 tree rings. The average tree-ring width does not generally decrease with age in these samples (no growth curve produced), indicating that the most important parameter controlling the radial growth in the trees is the temperature. According to Fritts (1976), the growth curve flattens as the tree becomes more stressed. For a tree on a limiting site near the tree line the effects of the growth curve would be very small because environmental parameters other than temperature decrease in importance and the temperature becomes the predominant growth factor (Fritts, 1976).

These long-living trees could be internally correlated to build up a floating chronology based on seven equally long driftwood tree curves (Table 3). This chronology could be synchronized with the living tree chronologies from the delta, giving high correlation values with the delta mean chronologies (Table 4), with its end year dated to 1986. Figure 5 shows the Tuktoyaktuk–Peninsula Point driftwood chronology plotted against the chronology from south of Inuvik. From the plot it can be seen that the average tree-ring width is lower in the driftwood chronology, indicating that the trees constituting the Tuktoyaktuk–Peninsula Point chronology most probably originated in the upper delta area, close to the northern limit of the woodland tundra.

The second group consists of driftwood samples from Separation Point (Fig. 1:D2), showing high internal correlation values. These samples were internally cross-correlated and six trees were used to construct a floating chronology (Table 3). This chronology could be synchronized with the chronologies from the delta and its surroundings. It did not give as high correlations with the delta chronologies as the Tuktoyaktuk–Peninsula Point curve did, but the Separation Point chronology is still easily datable, with its end year 1989 (Table 5). Figure 6 shows the Separation Point driftwood chronology plotted against the chronology from south of Inuvik.

Trees giving the driftwood chronology from Separation Point have their origin in the area south of the delta, possibly close to the sampling site. In this chronology, 40 driftwood samples from Separation Point could be dated, which is 45% of the analyzed samples from that area. Figure 7 shows the year of death of the dated samples from Separation Point. With the help of the Separation Point chronology, seven samples from the Tuktoyaktuk–Peninsula Point driftwood collection could also be dated, which is 6% of the analyzed samples from that area.

The third group of driftwood consists of relatively young trees from both of the sampling sites. These trees produced a growth curve indicating growth under more favourable

TABLE 3. Driftwood chronologies from this study

Number of trees	Number of rings	Sensitivity	Internal correlation	Time span	Possible origin of the driftwood
7	387	0.188	0.505	1600-1986	The delta area
6	169	0.173	0.546	1821-1989	S of the delta
3	157	0.190	0.514	1831-1987?	Liard River area
5	105	0.208	0.500	1883-1987?	Liard River area
5	139	0.217	0.566	1-139	?
7	120	0.214	0.550	1-120	?

TABLE 4. Correlation values of the Tuktoyaktuk–Peninsula Point (D1) driftwood chronology with chronologies from the Mackenzie delta (Fig. 1)

	Tuktoyaktuk–Peninsula Point chronology	
Site	t	Sign test (%)
N of Inuvik (S1)	13.12	73.2
S of Inuvik (S2)	17.91	76.6
Fort McPherson (S3)	2.58	63.0
Spruce Creek	15.50	70.4
Delta chronology	19.99	78.4
TT-HH	5.77	62.9
Separation Point (D2)	4.93	65.5

TABLE 5. Correlation values of the Separation Point driftwood chronology with chronologies from the Mackenzie delta and surroundings

	Separation Point driftwood chronology	
Site	t	Sign test (%)
N of Inuvik (S1)	8.38	73.2
S of Inuvik (S2)	7.11	69.0
Fort McPherson (S3)	4.31	67.9
Spruce Creek	5.62	67.9
Delta chronology	6.66	70.4
TT-HH	3.30	62.0
Tuktoyaktuk–Peninsula Point driftwood chronology (D1)	4.93	65.5

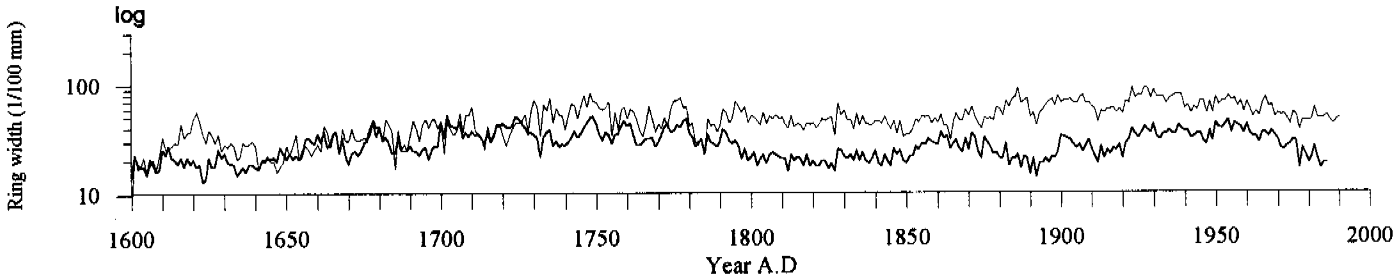

FIG. 5. The Tuktoyaktuk–Peninsula Point driftwood chronology (thick line) dated via the chronology from south of Inuvik. The t-value is 17.91 and Sign-test 76.6%.

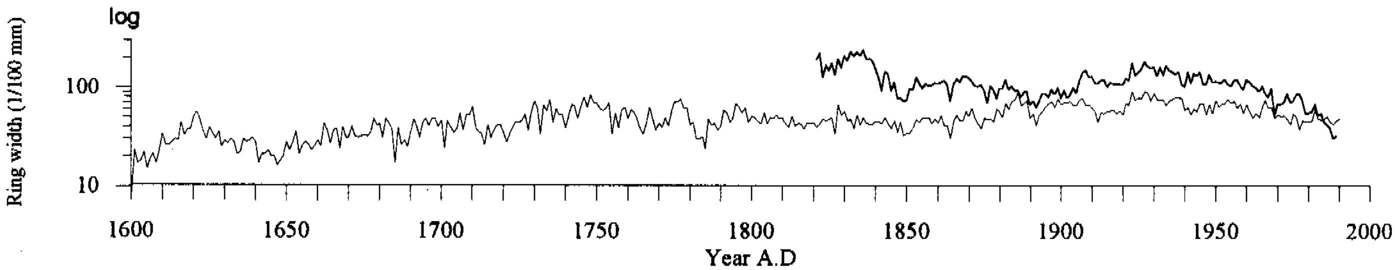

FIG. 6. The Separation Point driftwood chronology (thick line) dated via the chronology from south of Inuvik. The t-value is 7.11 and sign-test 69.0%.

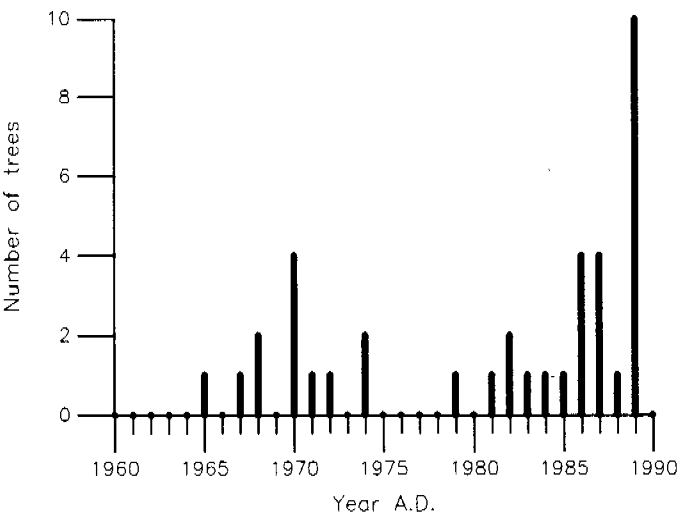

FIG. 7. Year of death of dated driftwood samples from the Separation Point area.

environmental conditions than those trees growing in the delta area. Wood density is lower than in older trees and reaction wood is more common. Internal cross-correlation is not as common as in the first two groups, but it was possible to build up four floating chronologies, with 3-7 trees in each (Table 3). Two of these chronologies gave relatively high correlation values with a mean chronology from the Nahanni Butte area (Fig. 1) (from Parker *et al.*, 1973), and the driftwood might therefore have its origin in the drainage area of the Liard River.

The fourth group consists of driftwood samples where not more than two trees can be joined into floating mean curves and which are not datable via any available chronology. A common feature of these samples are relatively few tree rings, 55-110, and compression wood is common, caused by tilting. These samples are therefore not good for tree-ring studies. Tilting occurs in trees that grow on unstable creeping slopes close to rivers, into which they eventually fall. From the pattern in the outermost tree rings it can be seen in many cases that the tree underwent stress before it fell into the river.

Many ice jams build up during ice breakup in the river and subsequent flooding causes erosion (Kindle, 1921). Many driftwood logs have scars that they probably received during such events.

When local people were asked if they knew the main origin of the driftwood, they usually thought it to be the Liard River or British Columbia. This is probably correct, because in the Rocky Mountains erosion is greater than in areas farther downriver. The ecological conditions in the Liard River drainage area seem to be different from those in the delta. The trees are much younger, have broad tree rings, and produce a growth curve, whereas the delta trees are older, with narrow tree rings and little evidence of a growth curve (Fig. 8).

North American Driftwood in the Greenland Sea

Driftwood can be found on the coasts of most islands in the north Atlantic Ocean. Most of this wood comes with the East Greenland Current via the Arctic Ocean (Fig. 9), probably to a large extent transported frozen into the polar pack ice (Häggblom, 1982). As the pack ice melts, the wood begins to float in open water until washed ashore on Greenland, Jan Mayen, Iceland, and Svalbard. Arctic driftwood is sometimes deposited on the Faroe Islands.

Driftwood collections from Greenland, Svalbard, and Iceland have been analyzed by the dendrochronological method.

The tree-ring pattern of six *Picea* driftwood samples from three localities on Greenland show high correlation values with tree-ring chronologies from Alaska or Canada but none of the samples from the driftwood collections on Iceland and Svalbard, although more than 200 driftwood logs have been analyzed from each of these localities. A dendrochronological

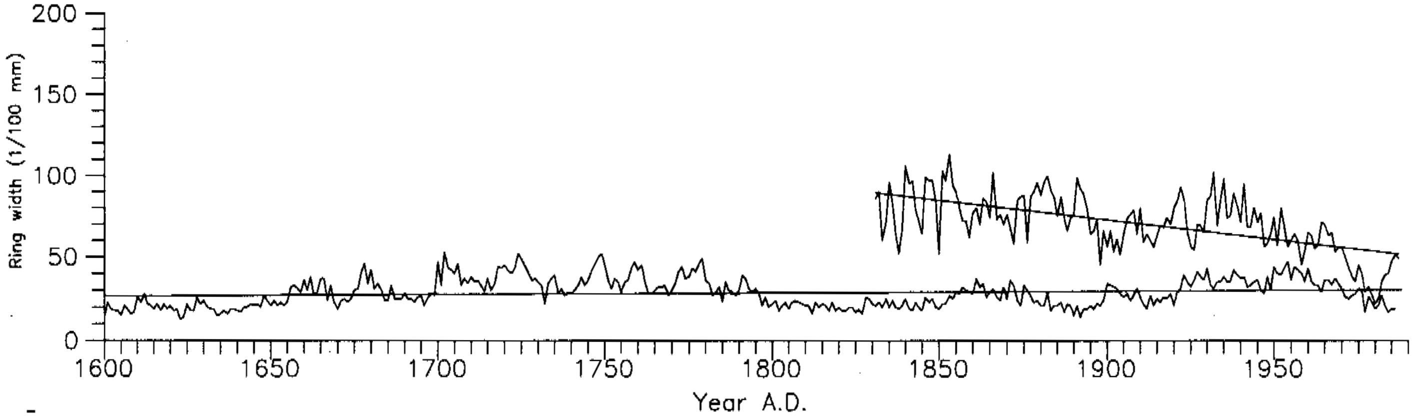

FIG. 8. Above: Tree-ring pattern of a driftwood mean curve with a probable origin in the Nahanni Butte area, producing an age curve. Below: Tree-ring pattern of the Tuktoyaktuk–Peninsula Point driftwood chronology, producing no age curve.

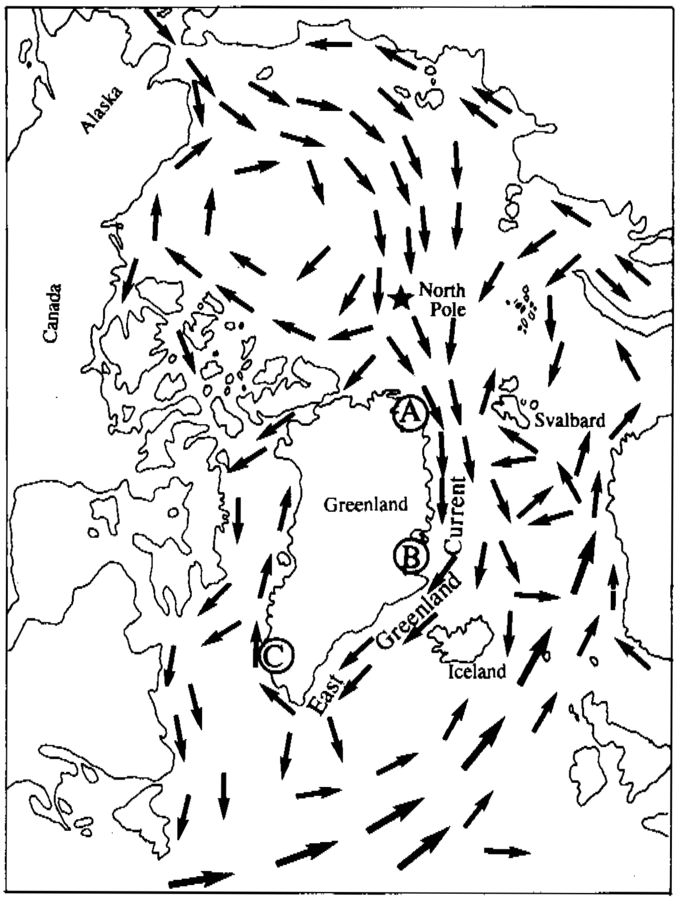

FIG. 9. The main arctic oceanic surface currents (modified from Bearman, 1989), with driftwood sampling sites in Greenland. A: Prinsesse Ingeborg Peninsula. B: Constable Pynt. C: Godthab.

and wood anatomical analysis of the samples from Iceland and Svalbard indicate their origin to be in the boreal and subboreal forests of Russia (Bartholin and Hjort, 1987; Eggertsson, 1992). To a large extent, the Greenland driftwood is probably also of Russian origin.

The first driftwood locality on Greenland is on Prinsesse Ingeborg Peninsula (Fig. 9A) in the far north (81°30′N; collected by Svend Funder, Geological Museum, Copenhagen, 1988). From this collection two spruce samples could be dated in American chronologies. One had a tree-ring pattern showing that it came from the Mackenzie delta (Fig. 10) and another one showing that it came from Alaska (Fig. 11). The outermost ring on each sample was dated to 1880 and 1923 respectively. The correlation values are shown in Tables 6 and 7.

The second is from Constable Pynt in Scoresby Sund along the central part of the coast (Fig. 9B) (70°N; collected by Christian Hjort, University of Lund, 1990). One spruce sample from this area could be dated via chronologies from the Mackenzie delta (Fig. 12) and one via chronologies from Alaska (Fig. 13), giving the date of the outermost ring as 1888 and 1905 respectively. Tables 6 and 7 show the correlation values of the two samples.

The third driftwood locality was in the Godthab area on the southwest coast of Greenland (Fig. 9C), collected by Holst in 1880 (Örtenblad, 1881). (This collection belongs to the Historical Museum in Stockholm.) Two driftwood samples from this collection could be dated, one in chronologies from the Mackenzie delta (Fig. 14) and one in chronologies from Alaska (Fig. 15), giving the date of the outermost ring as 1854 and 1831 respectively. The correlation values are shown in Tables 6 and 7. Figure 16 shows the tree-ring chronology sites in Alaska.

Because North American driftwood has only been identified in driftwood collections from Greenland and not in Iceland and Svalbard, the possibility exists that North American driftwood is mainly transported southwards along the western flank of the East Greenland Current, entering it from the northwest (Fig. 9).

SUMMARY AND DISCUSSION

In summary, 290 driftwood samples were collected from the Mackenzie area. Of them, 206 *Picea* samples were measured and analyzed, of which 60 (29%) could be dated in chronologies from the delta area. The remaining 146 samples (71%) could not be absolutely dated, possibly because of a lack of master chronologies from the Liard River drainage area and because of relatively few tree rings in some samples.

Six driftwood samples from the coast of Greenland could be shown to have a North American origin, three dated via

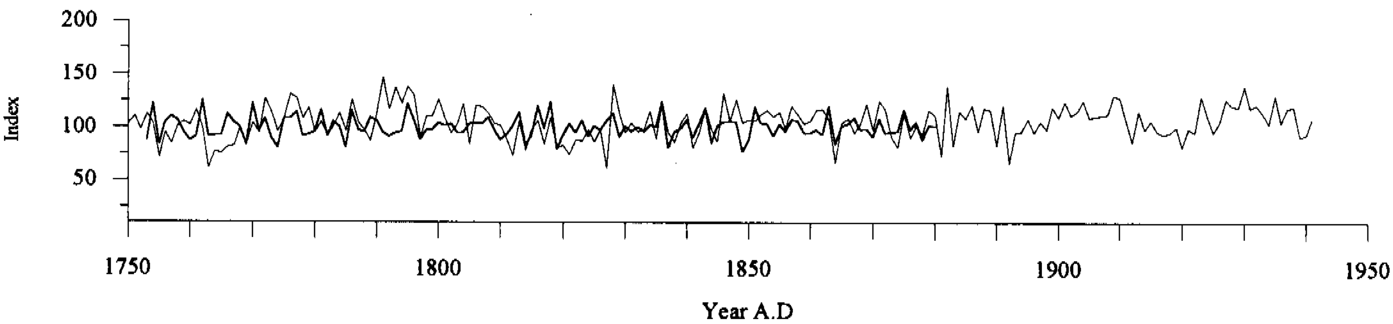

FIG. 10. Tree-ring pattern of driftwood sample from Prinsesse Ingeborg Peninsula, Greenland (thick line) and the Mackenzie delta chronology.

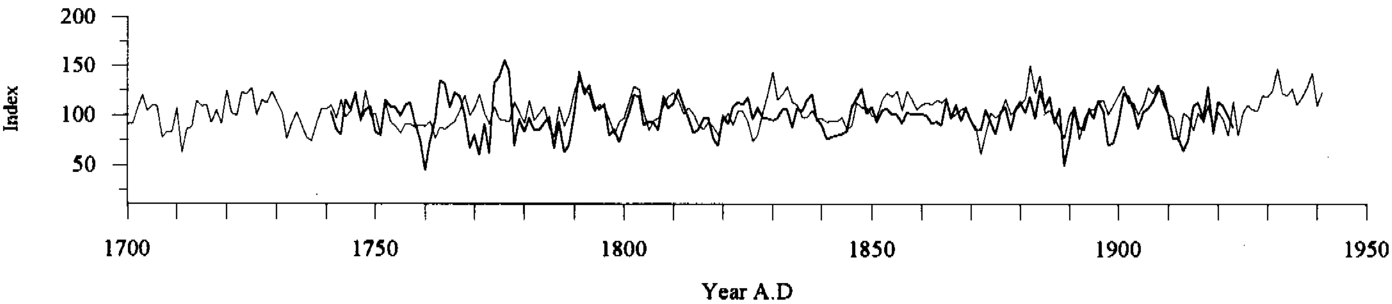

FIG. 11. Tree-ring pattern of driftwood sample from Prinsesse Ingeborg Peninsula, Greenland (thick line) and the Yukon River chronology, Alaska.

TABLE 6. Correlation values of driftwood samples from Greenland via chronologies from the Mackenzie delta area

	Ingeborg Peninsula, Greenland (A) (Fig. 10)		Constable Pynt, Greenland (B) (Fig. 12)		Godthab, Greenland (C) (Fig. 14)	
Site (see Fig. 1)	t	Sign test (%)	t	Sign test (%)	t	Sign test (%)
N of Inuvik (S1)	5.23	64.2	7.86	67.3	4.52	63.2
S of Inuvik (S2)	5.93	70.9	5.73	65.5	5.26	62.1
Spruce Creek	4.98	63.8	7.17	63.2	6.45	65.8
Delta chronology	6.10	63.8	8.26	64.6	6.08	63.0
TT-HH	4.02	65.0	3.73	62.2	3.43	60.7
Tuktoyaktuk–Peninsula Point driftwood chronology (D1)	5.10	66.5	11.06	70.8	7.42	64.1

TABLE 7. Correlation values of driftwood samples from Greenland via chronologies from Alaska[1]

	Ingeborg Peninsula, Greenland (A) (Fig. 11)		Constable Pynt, Greenland (B) (Fig. 13)		Godthab, Greenland (C) (Fig. 15)	
Site (see Fig. 16)	t	Sign test (%)	t	Sign test (%)	t	Sign test (%)
Koyuk			6.02	62.9		
Cape Darby			6.07	60.2		
Nulato	4.42	66.3				
Fort Yukon					4.90	64.4
Stephens Village					5.50	70.5
Yukon River	5.10	64.0	6.02	64.9	6.30	67.2
Alaska Range	6.02	65.9				
Nunivak Island driftwood	6.07	60.2	6.38	67.1		
Kobuk-Kotzebue sites			6.71	62.0		

[1]Chronologies from Giddings (1948, 1953), Oswalt (1958), Van Stone (1958), and Cropper and Fritts (1981).

tree-ring chronologies from the Mackenzie delta area and another three with chronologies from Alaska. None of the driftwood samples from the collections in Svalbard and Iceland has proved to be of American origin. This indicates that although some American driftwood is transported from the Beaufort and Bering seas to the North Atlantic and deposited on the coast of Greenland, American driftwood probably does not reach the islands in the central and eastern North Atlantic.

Dendrochronology on driftwood is more complicated than dealing with living trees. The researcher has only the wood sample in his hands but does not know the ecological conditions in the forest of origin. The known parameters are only the species, the sampling locality and the tree-ring pattern.

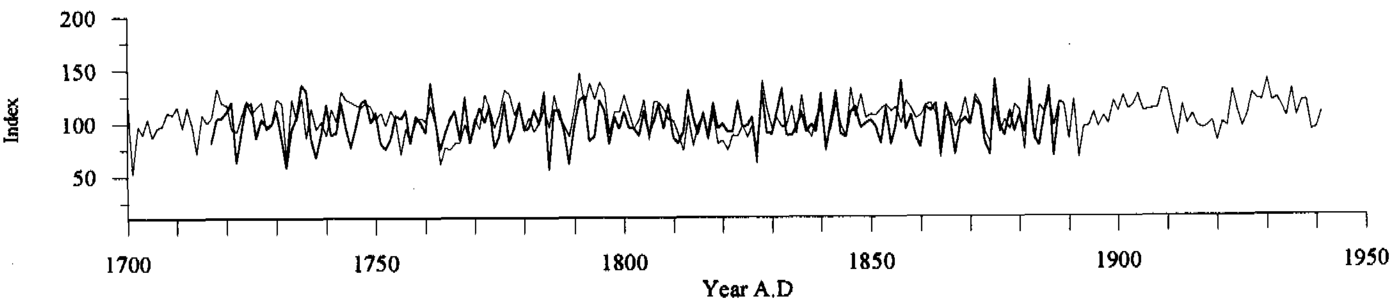

FIG. 12. Tree-ring pattern of driftwood sample from Constable Pynt, Greenland (thick line) and the Mackenzie delta chronology.

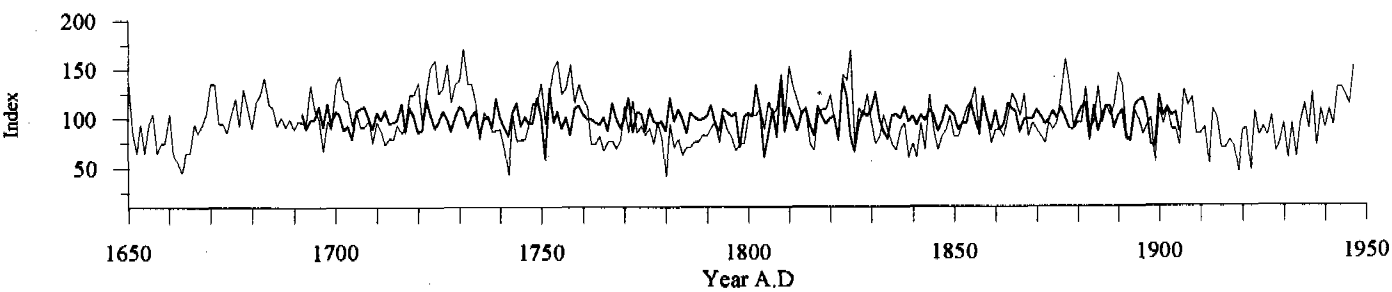

FIG. 13. Tree-ring pattern of driftwood sample from Constable Pynt, Greenland (thick line) and the Kobuk-Kotzebue chronology from Alaska.

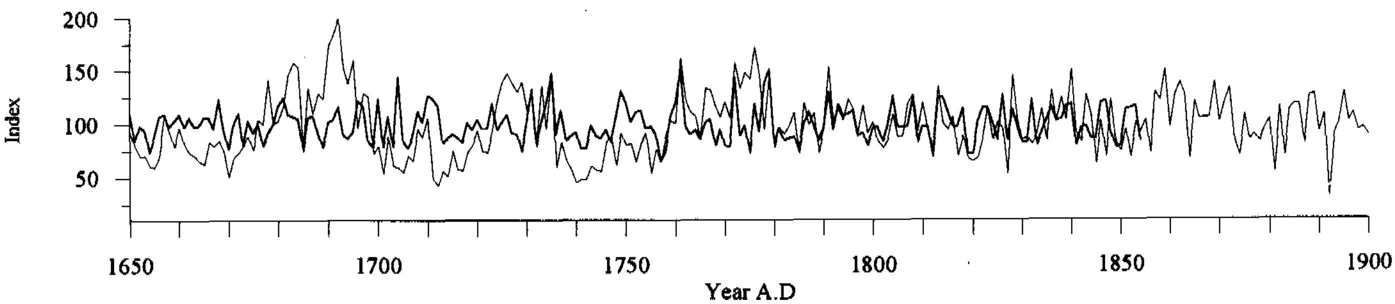

FIG. 14. Tree-ring pattern of driftwood sample from the Godthab area, Greenland (thick line) and the Spruce Creek chronology from Mackenzie delta.

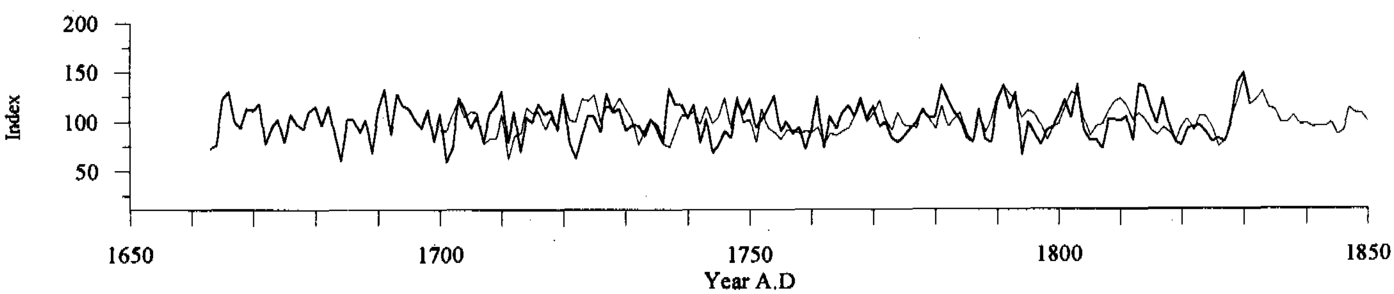

FIG. 15. Tree-ring pattern of driftwood sample from the Godthab area, Greenland (thick line) and the Yukon River chronology, Alaska.

The species may tell about the possible origin. *Pinus* does not occur in the Mackenzie material and does not grow in the watershed of the northward- and westward-flowing rivers in Alaska (Hustich, 1966). This means that *Pinus* driftwood logs found on the arctic shores most probably do not have their origin in the boreal forests of North America. The same can generally be said about *Larix*. Only one sample out of 290 from the Mackenzie delta was *Larix*, and according to Giddings (1953), it is a minor constituent of the Yukon river driftwood — but it is the dominant tree genus of eastern Siberia. The *Picea* species dominate in the American driftwood (*Picea glauca*) and are also common in western Siberia (*Picea obovata*) (Hustich, 1966). These two species cannot be differentiated by the anatomy of the wood.

The sampling site locality can often reveal the origin of the sample. Driftwood samples collected at Separation Point have their origin in the drainage area of the Mackenzie River, upstream from the delta. Samples from Peninsula Point came from all over the Mackenzie drainage area. When dealing with samples collected in Greenland, Svalbard, and Iceland,

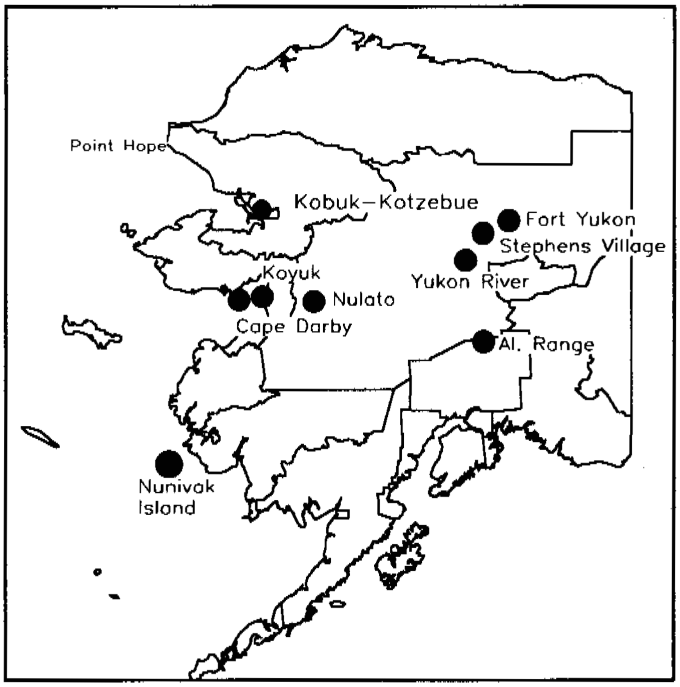

FIG. 16. Tree-ring chronology sites in Alaska.

a priori we only know that they originated somewhere in the circumpolar boreal forest regions.

The tree-ring patterns can tell us much more. With the help of master chronologies, the origin of the driftwood and the year when the wood began its drift can often be identified. This can only be done on a more regular basis if a good network of master chronologies from around the Polar Basin is available. The Mackenzie River chronologies presented here should be useful in identifying Mackenzie driftwood along the shores of the Arctic and Subarctic. Thus the chronologies will help in mapping the pattern and velocity of the ocean currents, the drift pattern of the polar pack ice and, as a possible extension, climatic fluctuations mirrored by changes in ice conditions indicated by varying driftwood frequencies.

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