Looking for signs of Climate change in annual growth rings of Northern Willow. (Salix glauca)

F.R.Sleight, January 2007.

For the

South Greenland Expedition 2006

Queen Elizabeth II High School
Peel
Isle of Man

Expedition Leader: Lesley Sleight

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Queen Elizabeth II High School , Peel, Isle of Man, **South Greenland Expedition, 2006.**
Expedition Leader Lesley Sleight, Teacher, Queen Elizabeth II High School.

Introduction.

In July/August 2006 a Duke of Edinburgh's Award Scheme Expedition, involving students from the School, took place in South Greenland. The month long expedition was a Gold Award Assessment and involved kayaking, walking and a residential project working on Greenland's first Arboretum at Narsarsuaq.
For a scientific element to the expedition the group decided to collect specimens of Northern Willow (Salix glauca) with a view to investigating the growth of the annual rings.
The idea for the investigation was prompted by a willow sample (Photograph 1) collected in 1999 on a similar expedition to the same area.
Northern Willow in Greenland is nature's Bonsai. In most areas it grows to only about half a metre tall, sufficient to slow the progress of walkers to a stumbling pace. The 1999 sample was "dead on collection" and well seasoned (photograph 1 shows this and the oldest of the 2006 samples). It proved to be 200 years old.
As far as can be determined the species has not been used in any previous studies

The idea was to collect specimens for measurement and hopefully relate the rates of growth to climate data. It was also an opportunity to set up protocols for further study, in particular for a collection of specimens during a Kayak expedition in 2007.

Sampling

It was decided to collect lengths of "trunk" about 100mm long. These would provide sufficient sections for mounting and measuring.
Nine sites were sampled, three trees from each. Locations were recorded using GPS or from the area Walking Maps (Saga Maps).
It was also intended to provide other site information such as associated species but the students did not have sufficient knowledge to do this. Some information was included when species were recognised.
Samples varied in diameter from 10mm to 25mm. They were stored in plastic bags with their location and any other data.

Measuring.

This proved to be difficult. All of the specimens had to be treated with preservative. There was evidence of fungal growth on several specimens- presumably a result of being returned to a warmer climate and stored in plastic bags.

The end of each sample was cut with a "razor saw" and then carefully cut across with a wide blade modeling knife. (We have no access to a microtome!) A single blade razor blade superglued to a wooden handle was then used to remove a final narrow cut across and through the central growth ring. A 3mm slice with this surface was the taken from the sample.
Under a large magnification of a compound microscope with top illumination it was impossible to see the boundaries between growth rings.

A very narrow line of cells only marginally different in colour/structure to the main growth separates each year's annual growth. The best results were obtained by using a stereomicroscope with 20x magnification – the exception being the 200-year-old sample that had much better definition (aided by linseed oil) where 36x magnification was possible.

Photograph 1. The sample collected in 1999. (Scale cm)

Photograph 2 gives some indication of the relative sizes of the oldest 2006 sample; 20065C-30 years old and of a Manx grey willow (Salix cinerea) of the same age. Interestingly the boundary layers between growth rings were very similar in size and difficulty of observation. The stereomicroscope was equipped with an eyepiece graticule (100 divisions), used as the measuring unit. The graticule was calibrated using a vernier stage mount onto which the samples were fixed (using a plastic modeling clay). Altering the angle of illumination proved to be the best way of exposing the differentiating layer between rings. Ring positions were recorded across the 100 divisions of the graticule as a running total. The sample was then moved across with the vernier mount so that the last 2 or 3 rings measured overlapped the start of the new graticule reading. It was possible to estimate to the nearest 0.5 of a graticule division- 100 divisions at x20 mag equaled 8.5mm and at x36 mag 4.6mm.

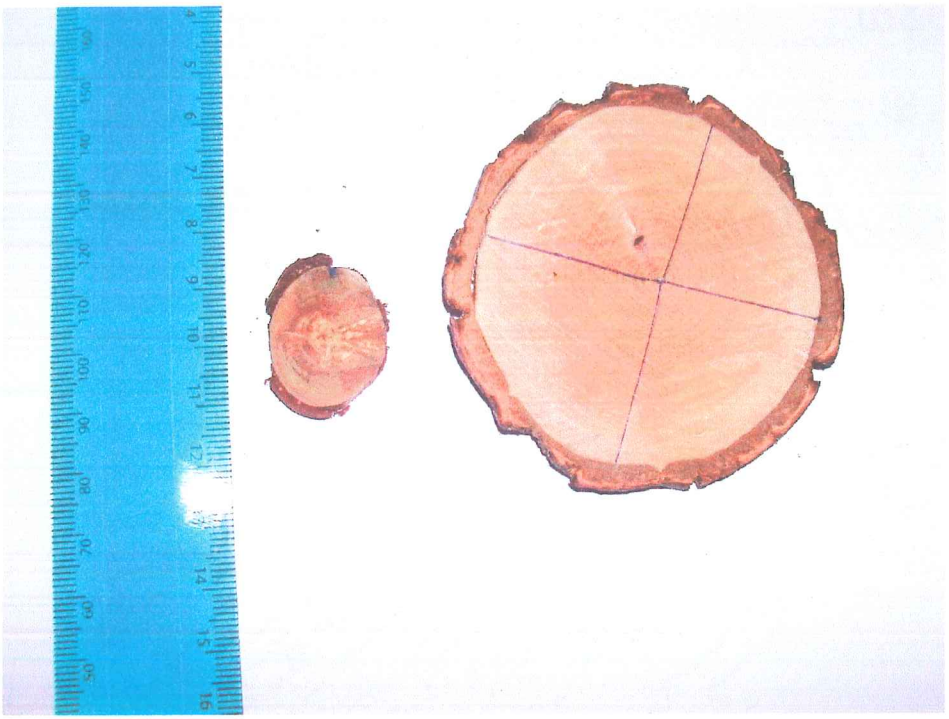
Where possible (except for the small diameter specimens) each slice was measured across more than one radius and if possible across a "diameter"

All measurements (in graticule units) were recorded in MS XL. Ring positions were then calculated from the core ring at the center of the section. In most cases rings were "lost" in the count. Some disappeared into each other when tracked around their circumference. In all cases the age of the tree was assumed to be the largest count of rings equivalent to years. The outer ring was 2006 growth and has been omitted from the graphs.

Individual ring widths were calculated from their positions relative to the pith core.

Samples across the same diameter labelled –d1, -d2. Any d1/d2 lists should match with the same number of rings but many do not. Some rings are lost in the last few years of growth, the outer rings. Some are just invisible.

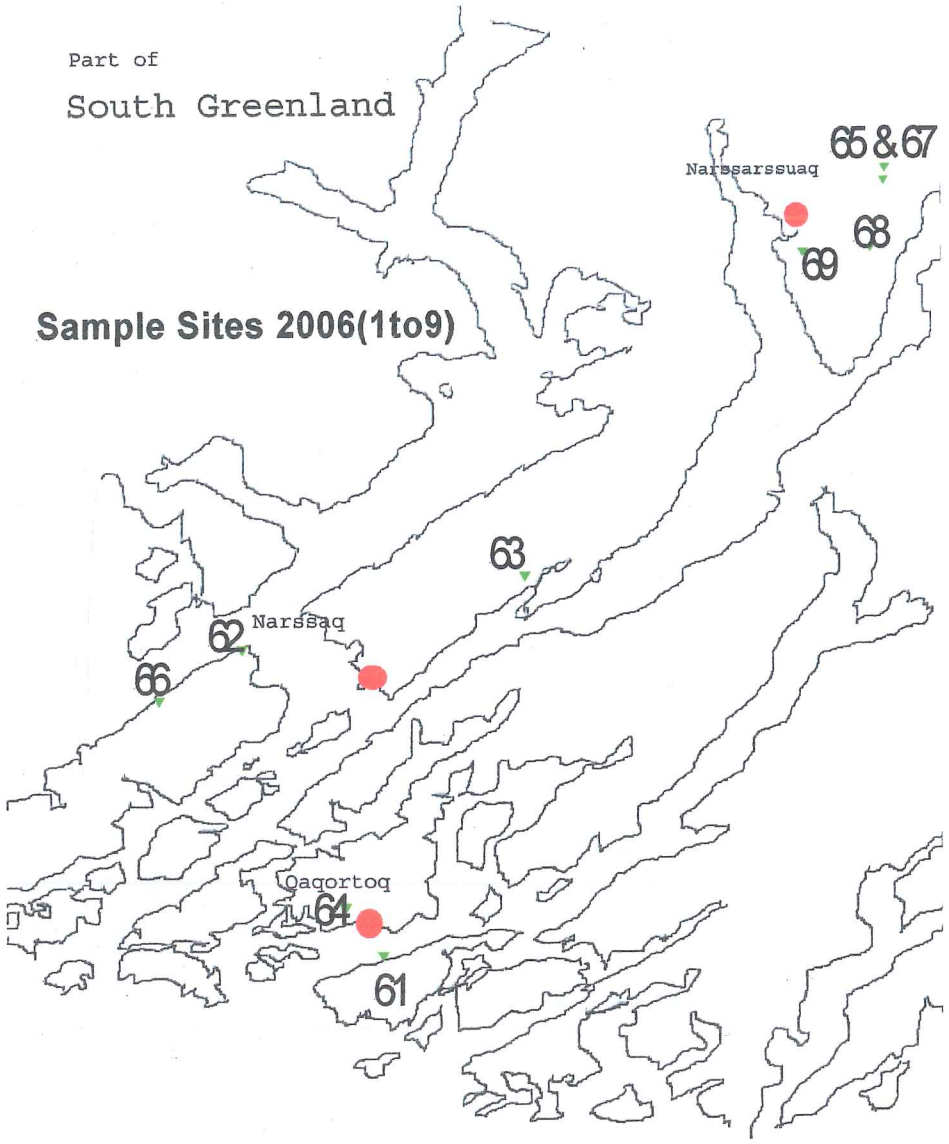
Measurements are all from same slice of limb unless indicated.
Samples labelled a, b, c, etc are the same sample but at different angles.



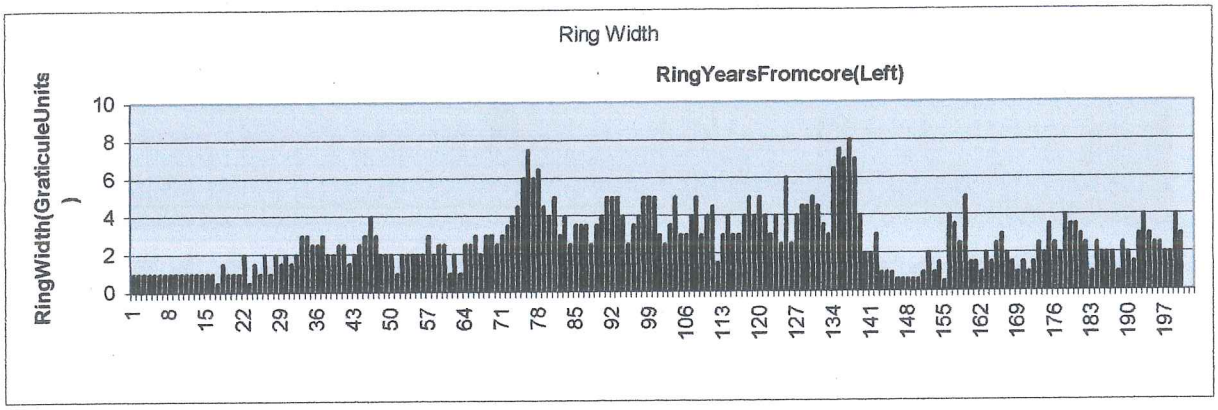
Photograph 2. Sample 20065C and Manx (S.cinerea), both 30 years old. (Scale cm)

Metadata
All samples collected July/August 2006.
All altitudes Sea level +10/20m unless stated.
Nine sites sampled, three limb sections from each site.
Labeled in MS XL as Sample 61, (=20061), 62, (=20062), through to 69, (=20069)
20061 Site GR 0445 67292
20062 GR 0435 6756, associated species- Hare bell, Broad leaf willow herb, Mares Tail, Dated 21/07 06.
20063 2nd campsite, (besides river), Other species- mosses, buttercups, hare bell, wild thyme. Dated 20/07/06
20064 Qaqortoq. 0443 6732 Alt=40m
20065 GR 0485124 6(or 0)786126, near lake, mostly grass, rocky.
20066 GR 04219 67480, rocky shore, mosses, grasses. Dated 23/07/06
20067 GR 0484511 6785261. Alt=600m. Boggy, grasses.
20068 GR 0482766 6784249. Alt=700m. Marsh, by lake.
20069 GR 0479409 6780881. Alt=500m. Next to river, slight ridge, mosses and grasses.

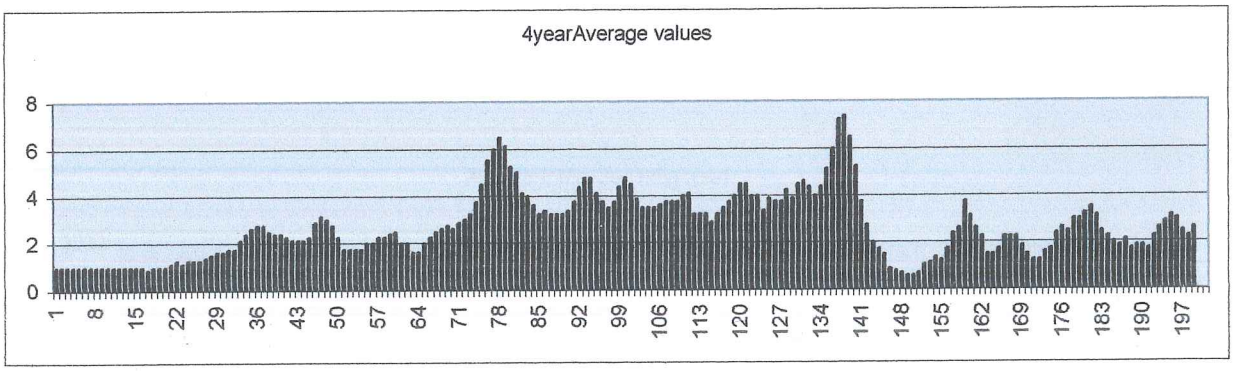
Map of Locations.



Measurements of (dead) Sample collected in 1999.



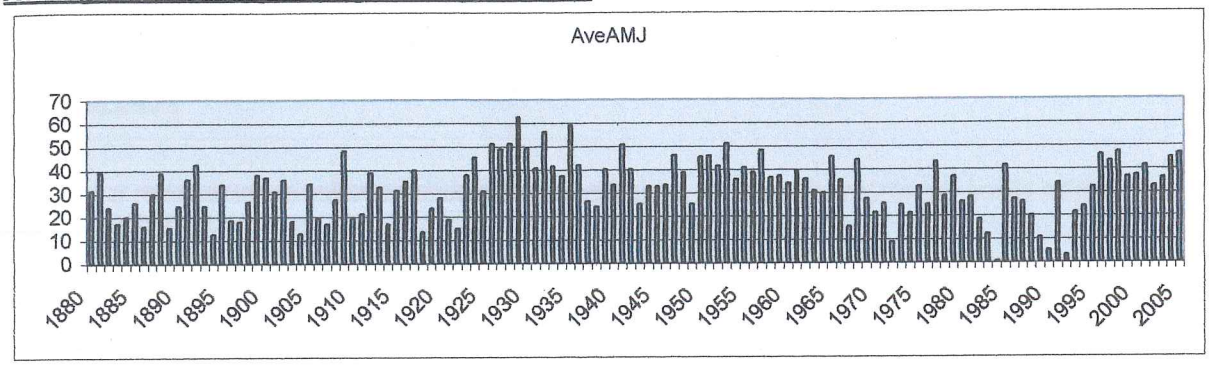
Ring widths (in graticule units – 100 = 4.8mm x36 mag) plotted against years of growth. The tree is 200 (possibly + 2 to 5) years old. It was dead and well-seasoned when collected in 1999 in the Narsaq area. One of the side branches measures 103 years old. The reduction in ring thickness from about 140 years old seems to have been the result of a loss of some 40% of bark on one side of the tree. The continued growth is measured on a side of the tree where the bark remained. There is also some bark loss at about 160 years leaving two areas of growth; the one above and a smaller sector with a total bark loss of about 50%.



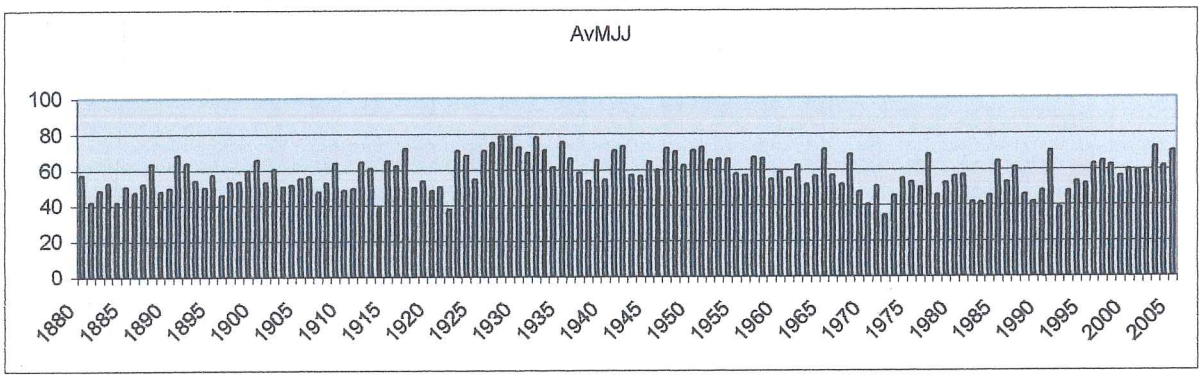
A running 4 year average is plotted above.
The sample could have been "seasoning" for a very long time, although it was decaying from the roots up into the trunk the climate obviously slowed the process down. The seasoning will also have resulted in some shrinkage of the specimen/ring widths.
There are no obvious correlations with temperature or precipitation records(Danish Metrological Institute data series 1768-2005- NARP data set, Greenland). The damage after 140 years growth means the remaining years growth rings are probably not reliable as indicators of environmental conditions although the growth was still quite vigorous.

(NARP – Nordic Arctic Research Programme.)

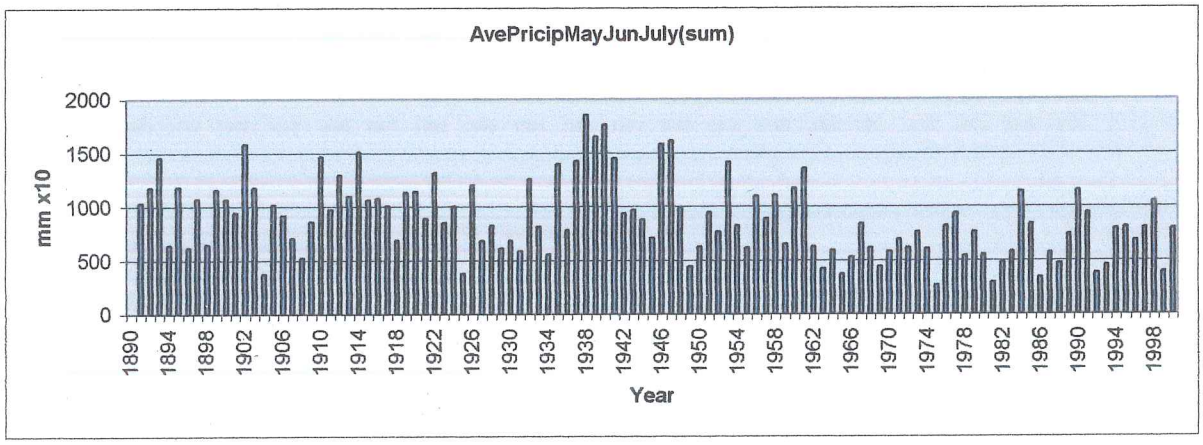
Average of "monthly average" Temperatures.



Average spring/early summer (April, May, June) temperatures x10.(NARP data).



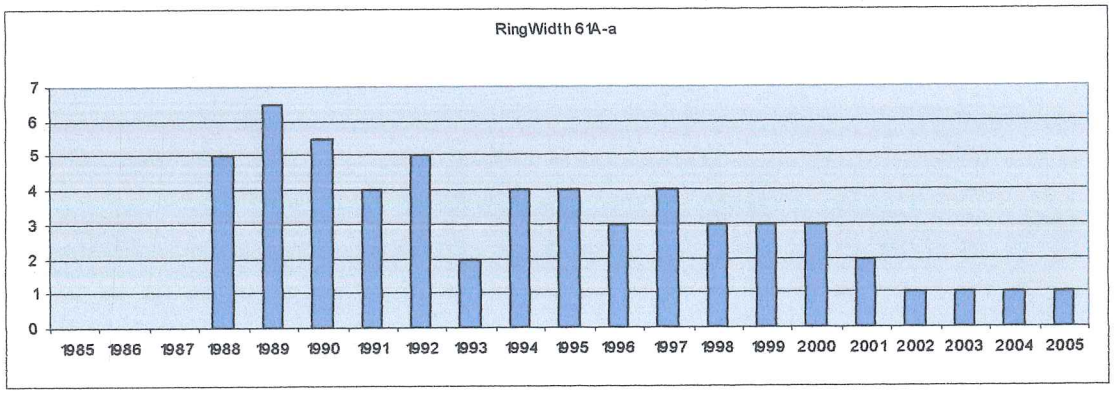
Average late spring/summer temperatures x10, (NARP data)

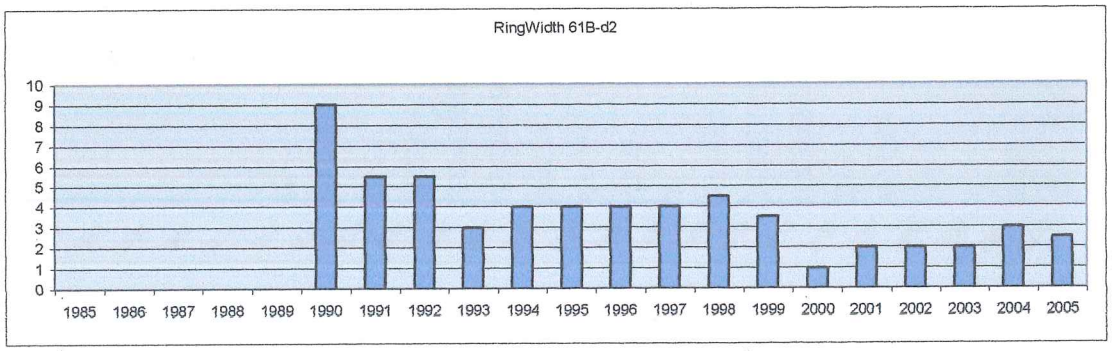


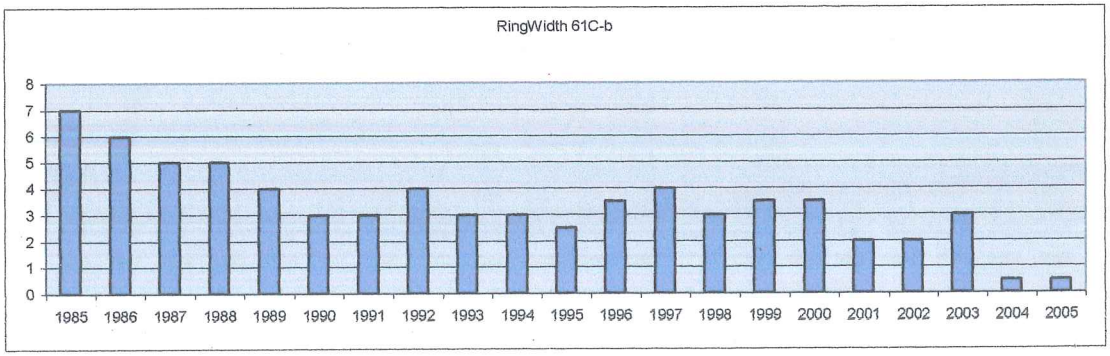
Average of monthly averages; summer precipitation 1890 to 1999. (NARP data)

Sample data.

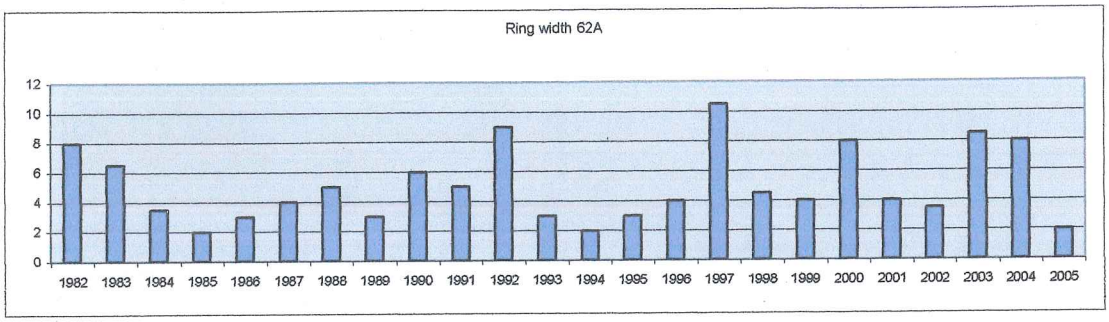
Below is a representative selection of data from the 9 sites. The graphs represent mostly older specimens but some young trees are included.
All graphs show ring widths in graticule units (100 units = 8.5mm, x20 mag)

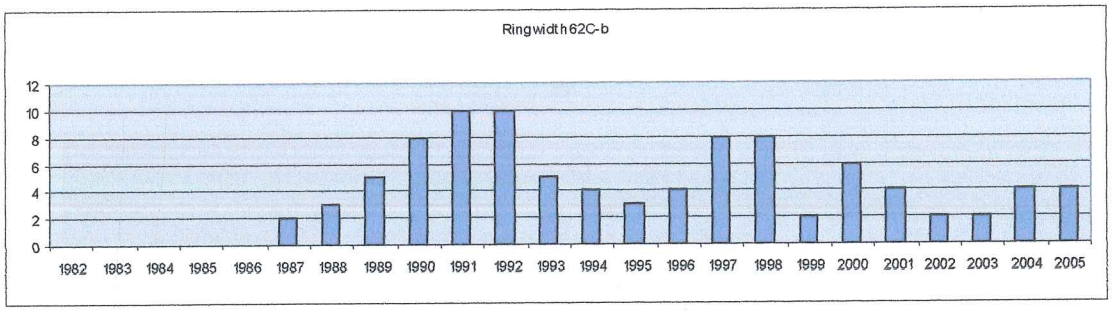


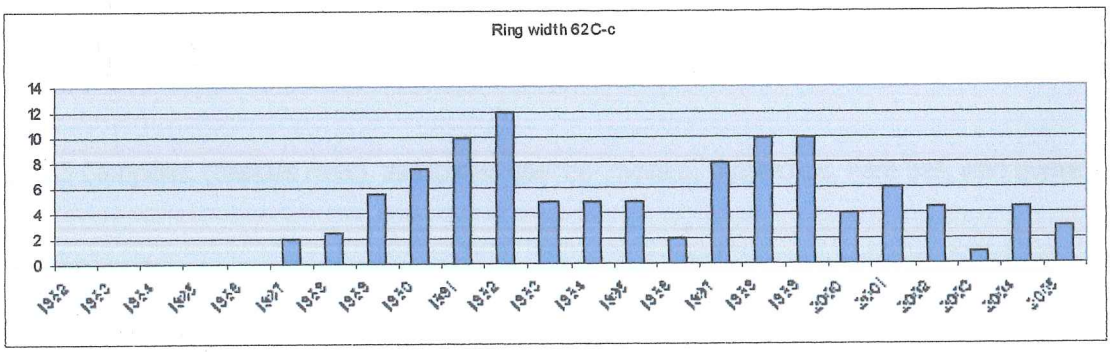




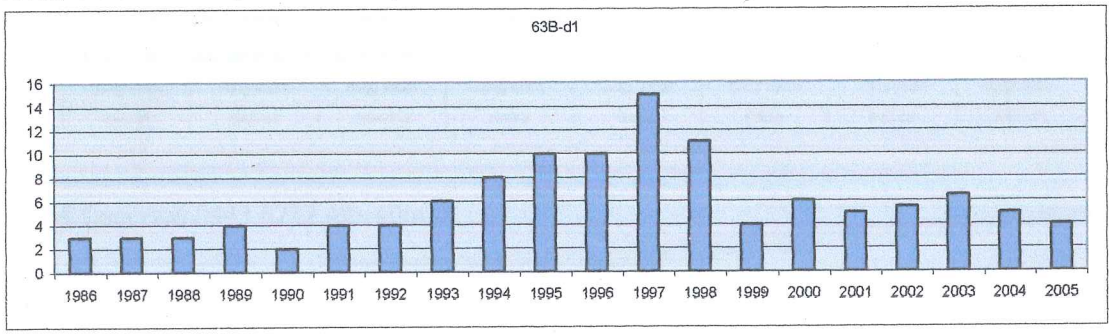
20061 Site GR 0445 67292

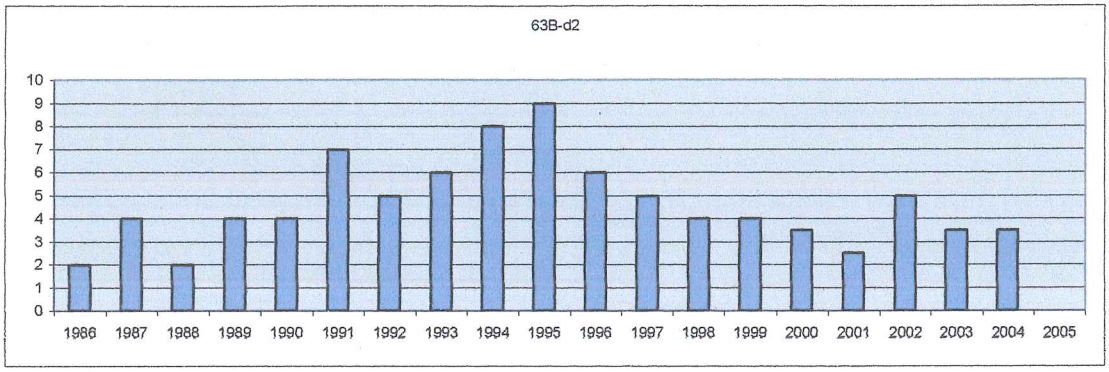


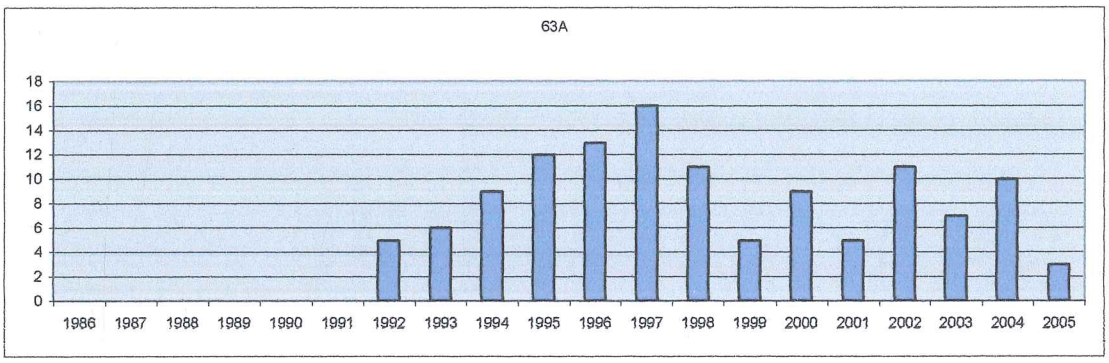




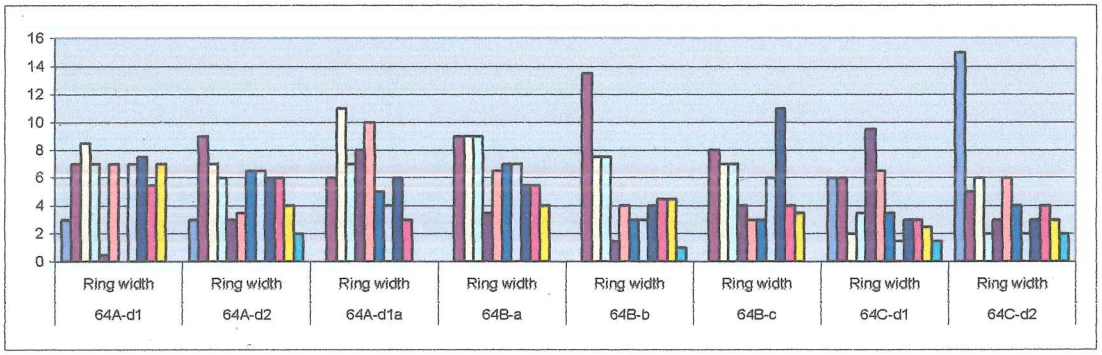
20062 GR 0435 6756, associated species- Hare bell, Broad leaf willow herb, Mares Tail,



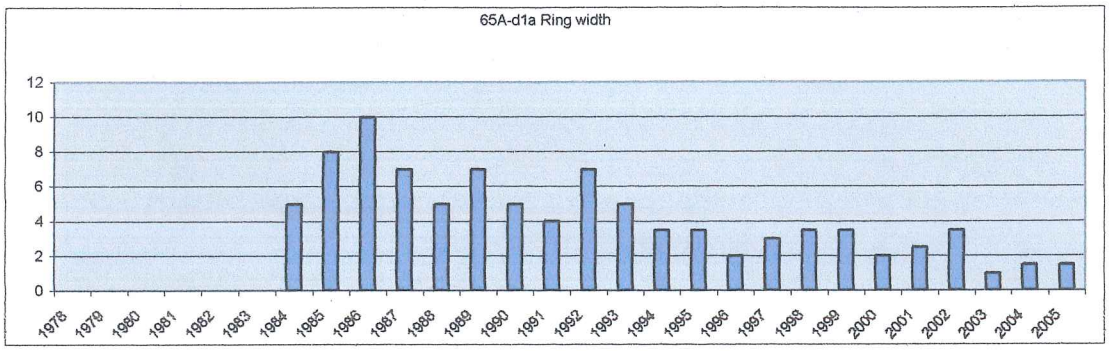


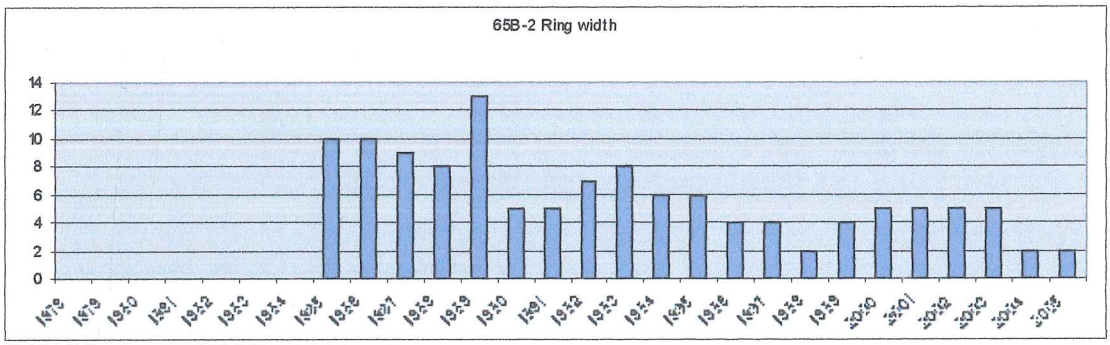


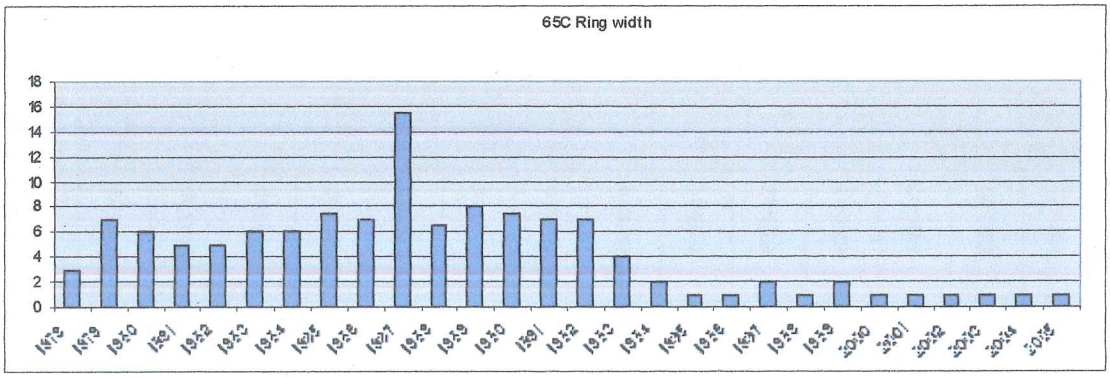
20063 Campsite, (besides river), associated species- mosses, buttercups, hare bell, wild thyme.



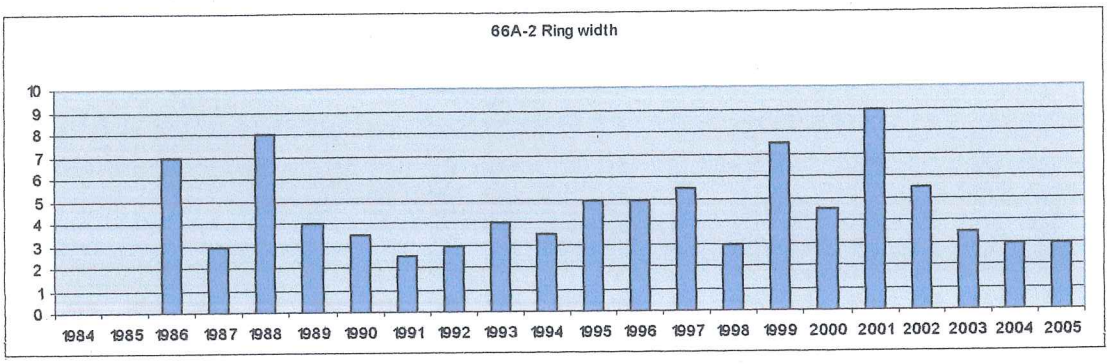
20064 Qaqortoq.0443 6732 Alt=40m

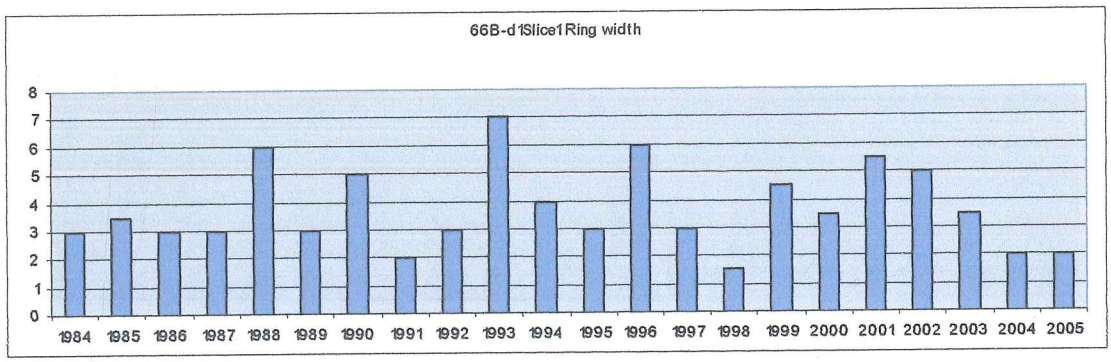




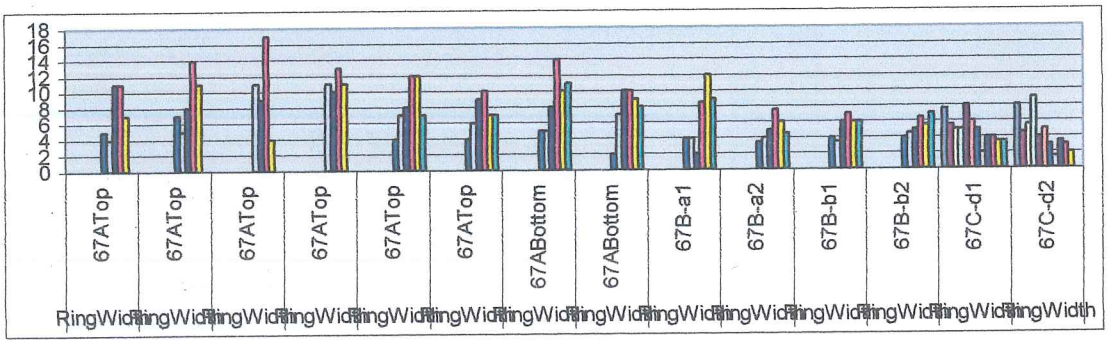


20065 GR 0485124 6786126, near lake, mostly grass, rocky.

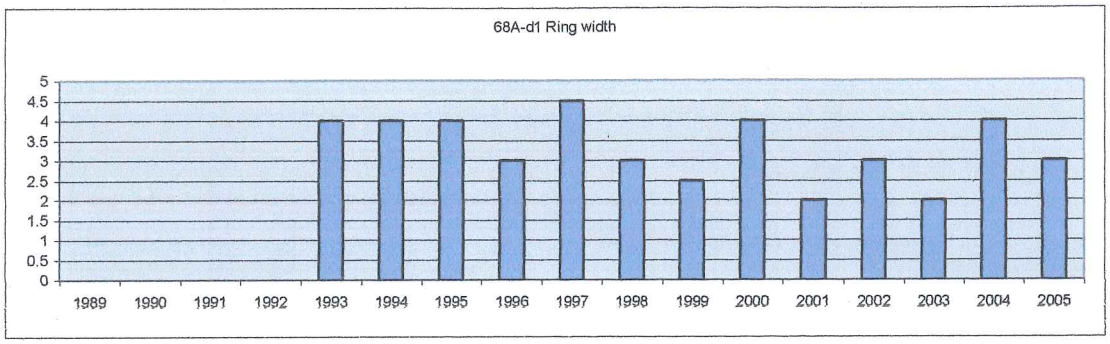


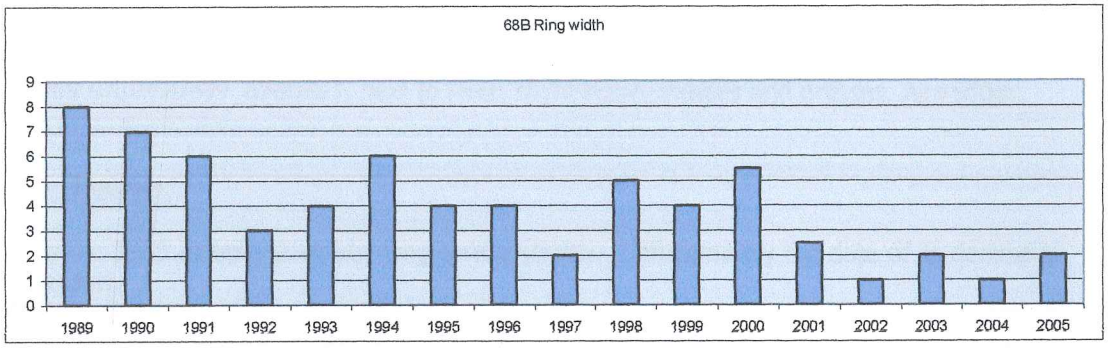


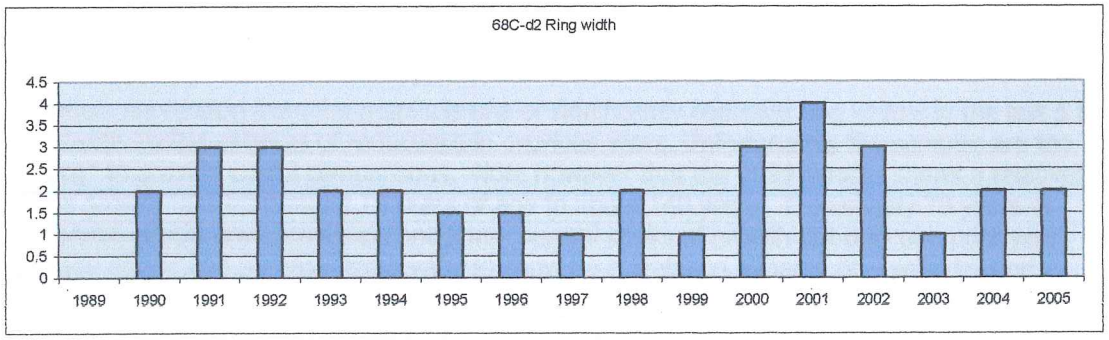
20066 GR 04219 67480. Rocky shore, mosses, grasses



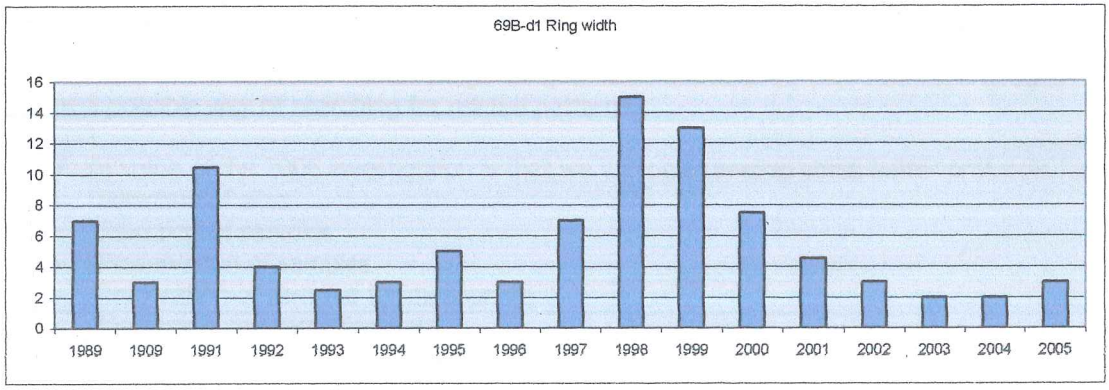
20067 GR 0484511 6785261. Boggy, grasses. Alt=600m

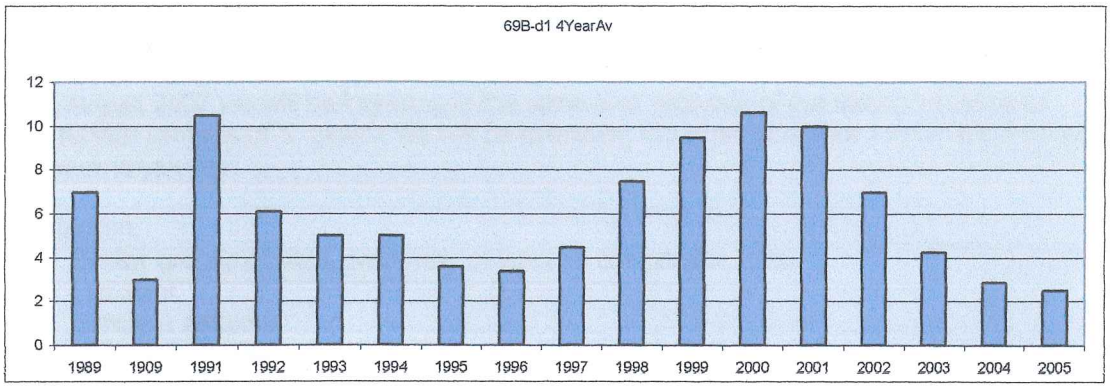






20068 GR 0482766 6784249, marsh, by lake. Alt=700m





4 year running average plot of previous graph.
20069 GR 0479409 6780881, next to river, slight ridge, mosses and grasses. Alt=500m

Conclusions.

Only the 1999 sample gives any long-term patterns. Unfortunately the date of its demise is unknown.
The 27 samples collected in 2006 show some patterns, particularly the oldest trees. Different ring width measurements from the same sample – measured across different radii generally show the same pattern though not the same dimensions. All of the samples showed asymmetric growth patterns.

The main impression from the graphs is one of significantly reducing ring widths in the last 5 to 7 years with similar patterns of reductions in previous years. Unfortunately the samples are too "young" to provide useful comparisons. Note however that the 1999 sample shows a relatively stable growth rate from about 70 years of age to about 140 years. Presumably 70 years of reasonably stable environmental conditions- several peaks of growth but only one poor year. Average Spring and Summer temperatures show no correlation either + or – with the ring widths.

Growth rates depend upon a number of factors: temperature, availability of water, availability of nutrients, duration of sunlight, snow cover, wind / ice damage and predation. The different sites have their own microclimates particularly when comparing sea level sites to those at altitude. The different factors could also work on different time scales, each year's growth being related to conditions in previous years. "Smoothing" the graphs by drawing 4/5 year running averages seems a possible way of searching for related patterns.

The main value of the 2006 investigation is that we can now develop some better protocols for:

- Selection of sites
- Selection of samples
- Preservation of samples
- Preparation of samples for measuring
- Measuring and recording data
- Data analysis

The present data will also be useful as a comparison with future results.

Suggested protocols for 2007.

In July/August 2007 we will be kayaking in the same area with one of our intentions being to collect further samples of S. glauca We will be extending the expedition area further West during the 3 week kayak trip.

Site Selection.

- Similar groups of sites, preferably at least 10 comparable sites.
- Sea level
- Different Altitudes
- Proximity to water
- Similar aspects
- Similar slope/drainage régimes

Description of sites must include:

- GPS Grid ref.
- Site description – including substrate, aspect, general geographic info.
- Extent of S. glauca growth with size of plants.
- Associated species – with specimens where appropriate.
- Altitude of site.

Selection and storage of Specimens; living samples are needed to "overlap" data with dead ones.
Need to remember that the trees though small could be 200 + years old, sample sparingly.

- Sections must be cut at ground level.
- Older specimens preferably with a short life expectancy but with some living tissue.
- Some dead/seasoned specimens – old! (can easily be confirmed with a sharp knife and hand lens)
- Some younger specimens for comparison, need to be 50 years old minimum
- Suggest minimum of 3 samples from each site of living specimens, several dead specimens if available.
- All specimens to be labeled with site location and unique ID.
- Specimens to be about 100mm long, cut ends dipped in hot paraffin wax, wrapped in "cling film" after air-drying.
- On return specimens to be stored without film in cool store (refrigerator)

Measuring.

- Surface preparation is most important. Still some need to experiment with techniques. A sharp microtome blade, suitably mounted could be the solution. Sections up to 400 mm diameter are possibly required.
- Cut sections to 3 to 4 mm thick after surface preparation.
- Stereo microscope with eye-piece graticule and vernier stage are adequate.
- With better surface preparation it should be possible to make several measurements of each section on different radii.

Data analysis.

- All measurement data recorded in XL
- Need to find some way of "un- losing" lost rings – when counts differ on the same sample.
- Same sample data needs to be "averaged" in some way.
- Possibly employ "Statistical software" for analysis - if affordable.

What do we hope to achieve?

With luck there will be some overlap of ring data between different age specimens, particularly dead ones. A bonus outcome would be to find out how efficient the climate is at preserving the seasoned wood; it may be possible to determine for how long it will last before decaying. It would also be useful to find out how much shrinkage occurs as the wood dries and seasons. Growth rates of living and seasoned material could then be compared. This would give a record of seasonal growth for many decades, possibly several hundred years from pocket sized samples!

It would be most encouraging if we could see any relationship between the tree ring data and climate records.

All temperature precipitation records supplied by Danish Metrological Institute :

Technical Report 05-05
DMI monthly Climate Data Collection 1768-2004,
Denmark, The Faroe Islands and Greenland
Authors. John Cappelen, Ellen Vaarby Laursen, Peter Viskum Jørgensen and Claus Kern-Hansen

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