

A collection of short notes on determining the age of Douglas-fir trees on Gabriola Island, BC, by the tree's chain-saw stump diameter or its DBH

Please be aware that this collection of notes is not the result of a comprehensive, academic study and very few trees were involved, far fewer than needed to establish any form of equation by the non-linear regression analysis that might be expected in a more professional work.

It was put together more in response to casual questions when surveying a stump or a mixed stand like “how old do you think it was/they are?”.

All trees were either isolated individuals or on land that had been logged, but left to itself and not regularly managed in any way as part of a working commercial forest.

Gabriola is one of the Canadian Gulf Islands in SW British Columbia, just north of the border with the Pacific Northwest (PNW) area in the USA.

The age of a Douglas-fir tree on El Verano, Gabriola

Tree 1

Determining the age of a Douglas-fir (*Pseudotsuga menziesii*) by counting rings is a dendrochronological technique that appears to work on Gabriola ([File: 264c](#)), but there are problems that prevent its use more often. Obtaining a core sample from a living tree requires the expert use of an increment borer, and there is always a risk of injuring or contaminating the tree. Douglas-firs of any age acquire a thick and corky bark, and if you don't know what you're doing, it's easy to jam the borer or have it twisting uselessly in a void or patch of rotten wood or have it pointing in a direction that misses the pith in the centre of the trunk.

The remedy for non-professionals, sad though it may be, is to wait for a chain-saw to provide access to the tree's interior. This happened to a veteran Douglas-fir on El Verano Drive on Gabriola.

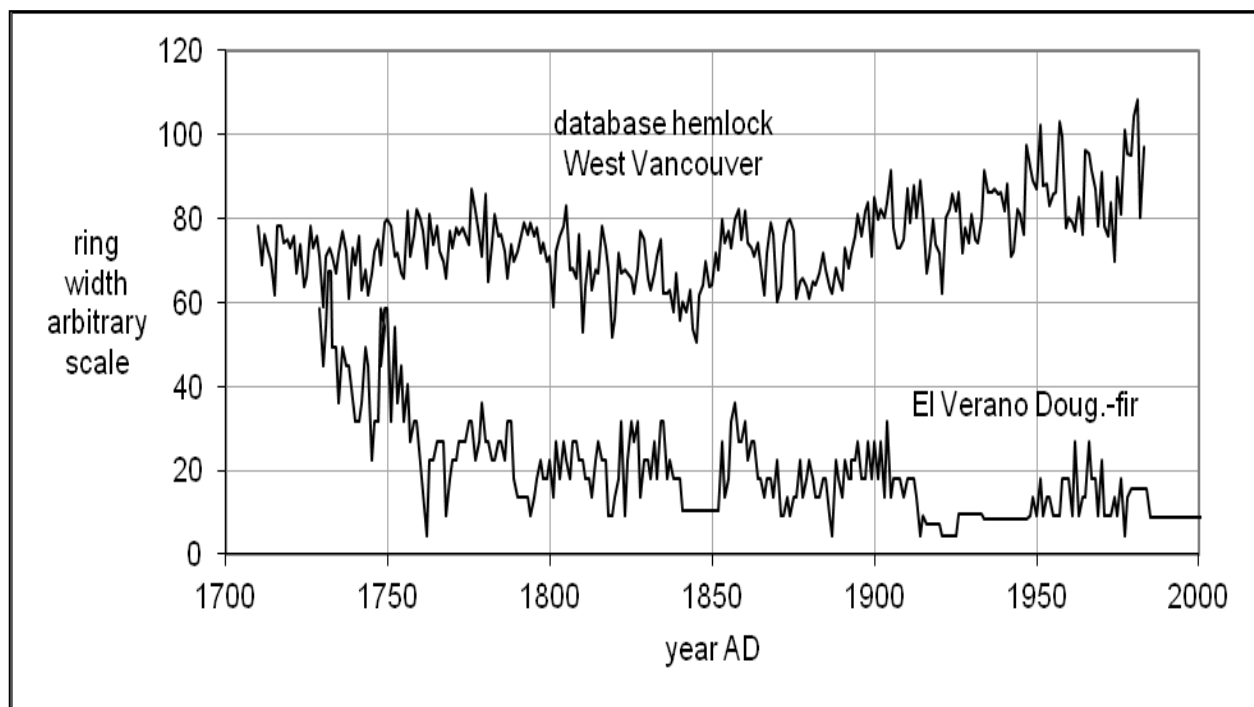
For reasons only making sense to somebody newly-arrived on the island—it appeared to be healthy—the tree was felled in February 2005. Its diameter at the cutting height without bark was 124.8 cm and its circumference allowing for bark would have been around 4.2 m.



This was not the biggest Douglas-fir tree on the island. The Gabriola Land and Trails Trust (GaLTT) keeps a “[big tree registry](#)” and it has records in 2020 of a dozen still-living trees with circumferences that average over six metres; but it was big enough that it must have escaped all post-settlement commercial logging.

The cut was photographed just a few days after the foul deed was done so that analysis could proceed without getting fingers frozen. I was interested in not just counting the rings but recording and dating their widths to see what evidence there was of major events in the life of the tree, which was growing on a very large midden.

Drought is recorded by smaller than average growth that year¹ or even in extreme conditions missing rings, while the removal of neighbouring trees by whatever means is recorded by a sharp rise in growth as more light and moisture become available. Although Douglas-fir is one of the preferred species for dendrochronology on the west coast here, false rings (two per year) do sometimes occur in years when there was an unusually abrupt change in the weather. To counter missed and false ring errors, I matched the tree-ring pattern with one held in a database at the World Data Center for Paleoclimatology, Boulder, Colorado, USA. Its pattern is not ideal being for a western hemlock (*Tsuga heterophylla*) in Cyprus Park, North Vancouver, but it is reliable and has proved to be very useful.



The tree’s ring pattern extended back to the year 1726 in the centre of the cut. Its pith was intact, so it was about 278 years old at the cut height in early 2005.

To this date we have to subtract the number of years it took for the tree to reach the cut height from its establishment as a seedling. I did not record the height of the chain-saw cut above root

¹ Growth at the southern BC coast is more often limited by summer drought than low temperatures while the reverse is true in the alpine and more northerly latitudes.

level though it was likely less than the BC standard breast height of 1.3 m on the up-slope side,² but this uncertainty is not a serious concern as the number of years the tree took to grow to this height can, in any case, only be guessed at being dependent on both local and global circumstances. The “standardized guess” I use is 12 ± 5 years for about a metre above ground, implying the tree was “born” *circa* 1714.

While it is attempting to identify exceptional growth or lack of growth years to particular global events, no conclusions can be confidently reached on the basis of the ring-pattern of just one tree. The low growth in the year 1887 might be associated with the extraordinary harsh winter in North America of 1886-1887 if it were not for the fact that the anomaly is not seen in the ring-patterns of other trees on the island. There was nothing special about the 1883/4 growth following the eruption of Krakatoa, the finding of which was the original aim of the project.

What is apparent in the pattern however are the two periods of very low growth and very crowded rings in the years 1841-1852 and 1920-1940. In a study of multi-year droughts in the Pacific Northwest,³ ([File: 2106c](#)), droughts were identified in six periods since 1750 and among these were the periods 1840–1852, 1920–1928, and 1931–1940, an almost perfect match with low-growth periods seen in the El Verano tree. ◇

² If a guess is absolutely necessary, I take diameter with bark at chain-saw height to be 1.05 times breast height (DBH). This rule I found empirically based on just two or tree measurements (this is not a PhD thesis) corresponds reasonably well with the Wensel and Olson (1995) formula I found [somewhere](#) on the web: $d = \text{DBH} \cdot \exp(0.04302 \cdot (4.5 - h))$. My rule of thumb is to multiply diameter inside bark (dib) by 1.08 to allow for bark when needed but not recorded.

³ Gedalof, Ze"ev; Peterson, David L.; Mantua, Nathan J. 2004. *Columbia River flow and drought since 1750*. Journal of the American Water Resources Association. December: 1579-1592.

The age of a Douglas-fir tree SW ¼ Section 19

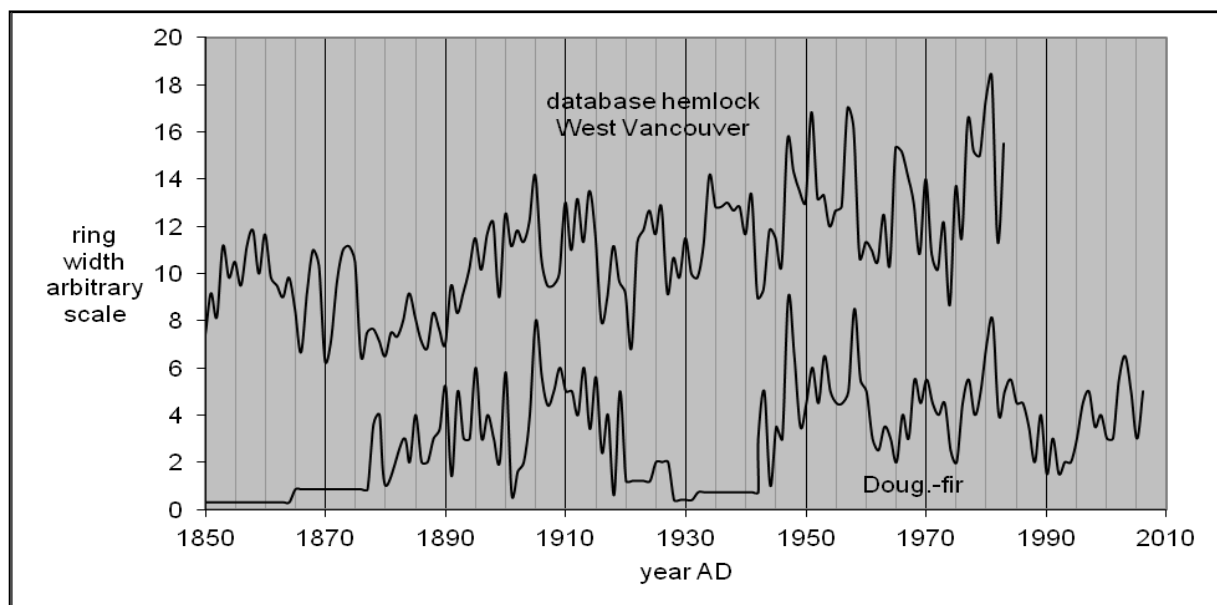
Tree 2

This is the tree that was studied and reported on in [SHALE 8](#), p.34, June 2004. It was in the woods in the SW ¼ Section 19 north of the school close to the border with NW ¼ Section 19.



Its diameter at the cutting height without bark was 74.4 cm and its circumference with bark would have been around 2.5 metres. The pith had rotted out as is common in these trees.

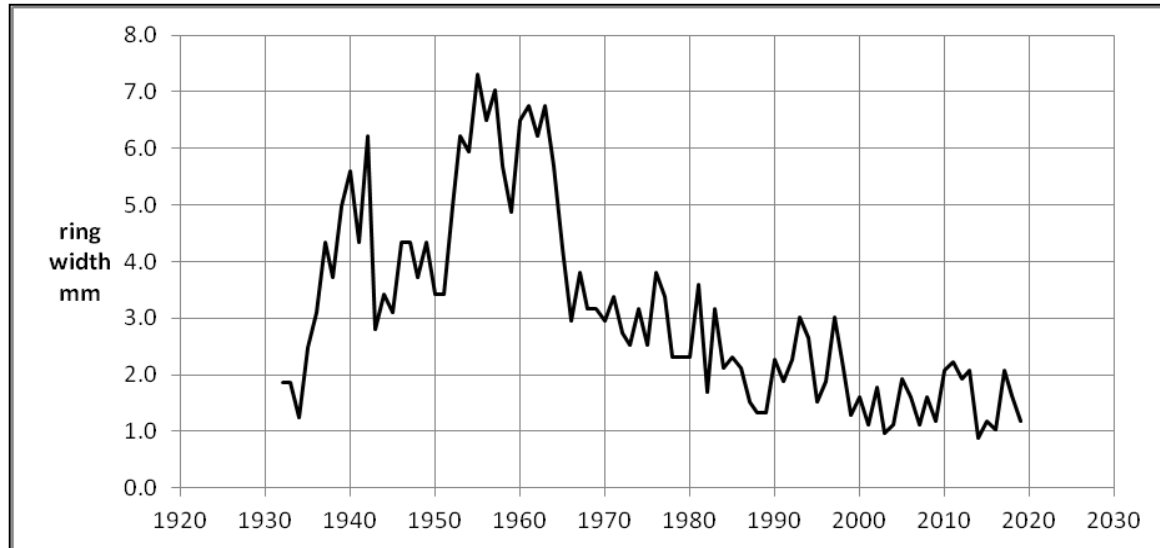
The tree's ring pattern extended back to 1862 before reaching the missing pith. I estimated that roughly 12 years were missing, pushing the date back at the cut height to around 1850. The cut was made in 2003, making it then 153 years old, implying a "date of birth" *circa* 1838. ◇



The age of a Douglas-fir cut in 2019/20

Tree 3

A tree with a very nice ring-pattern cut apparently for trail maintenance on the Federal Lands close to Joyce Lockwood Park on the north coast of the island. Its major and minor axes at the



cutting height without bark were 58.4 and 50.8 cm giving a theoretical perimeter of 1.7 m. Measured with bark was 1.9 m. The 1.7 m perimeter was taken to be a 54.7 cm circular no-bark diameter equivalent.

Rings were counted back to 1931 making it 88 years old at the cut height in late 2019 implying a “date of birth” *circa* 1919; however, no attempt to check this against the database standard, the match does not seem to be very good, so it is possible that there are false-ring errors in this

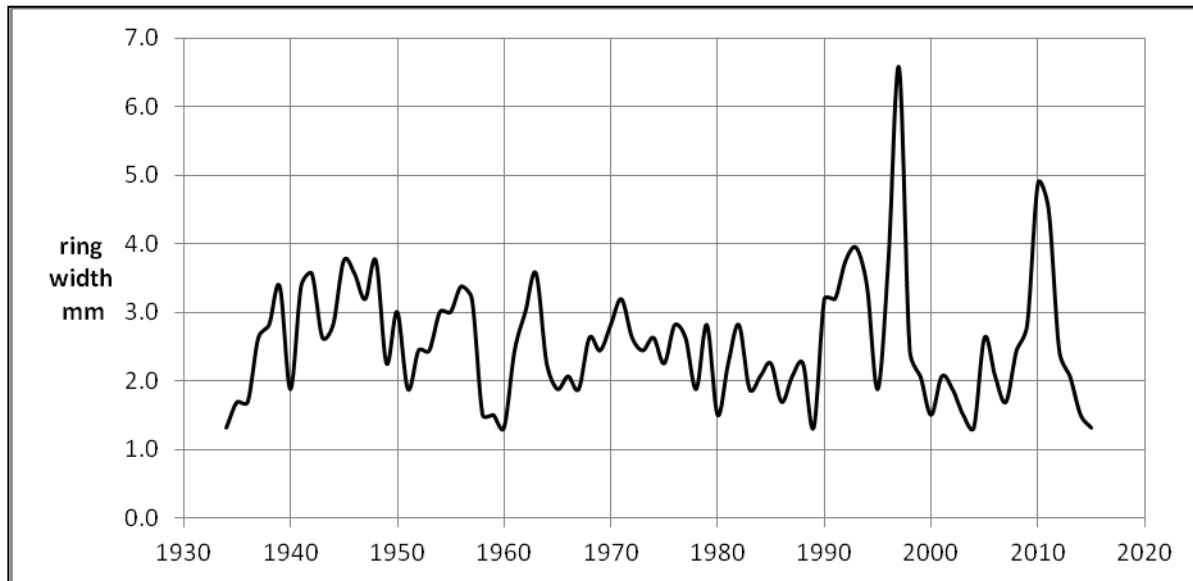


estimate making it seem a little older than it actually was. ◇

The age of a Douglas-fir tree SW ¼ Section 19

Tree 4

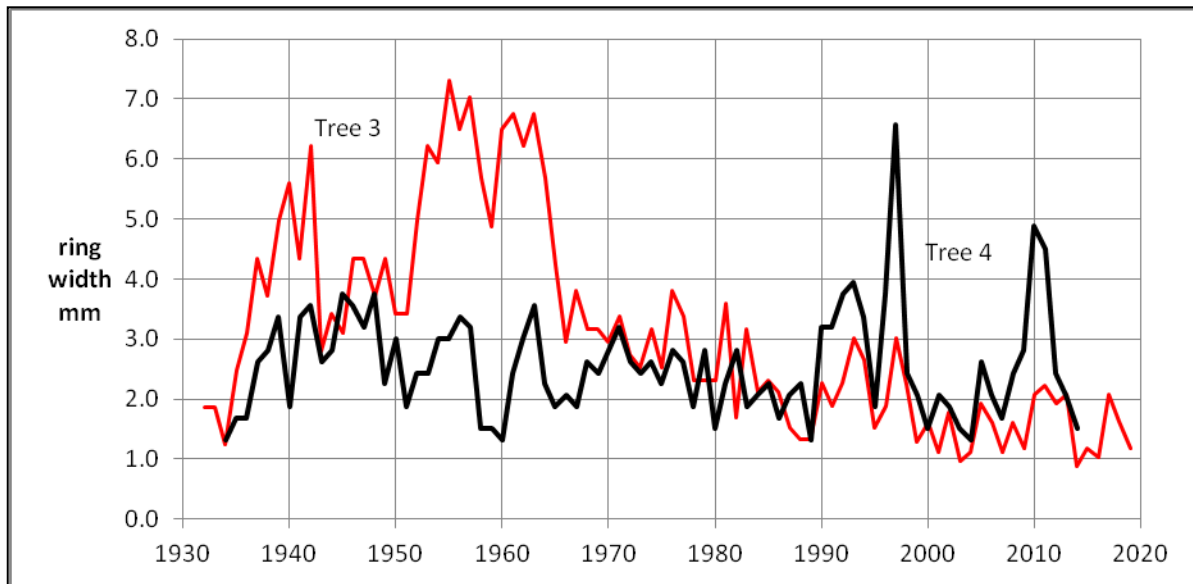
This tree had fallen, probably windthrow as a result of root rot, and salvaged in 2020 in the SW ¼ Section 19 just 15 metres into the woods from the Paisley Place roadside. It had fallen away from the road. Its diameter at one metre above root level without bark was taken as 41.9 cm. The measured circumference with bark was 1.42 m. A ring-pattern match of this tree with that of Tree 3 indicated that the tree had fallen in 2015.



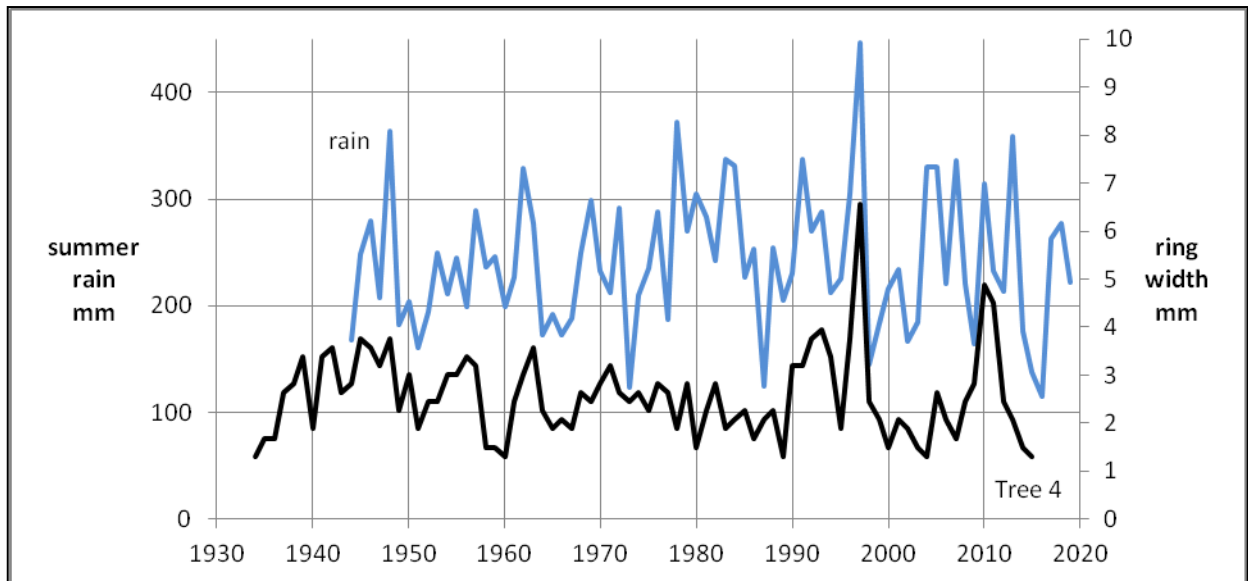
Rings were counted back to 1933 making it 82 years old at the cut height in 2015 implying a “date of birth” *circa* 1921. This is practically an identical life span to Tree 3, although its growth was less than that of Tree 3.



The age of a tree cannot be accurately predicted from the BC forestry standard diameter at breast height (DBH) without taking into some account the site growing conditions as a comparison of the ring-patterns of Trees 3 and 4 illustrates.



Another interesting comparison of patterns is that between the ring-pattern of Tree 4 and precipitation on the island during the six months of summer (April-September). It is even possible to see that there are probably one or two false ring counts in the Tree 4 record. ◇



The age of a second Douglas-fir tree SW ¼ Section 19

Tree 5-1 and 5-2



This tree had also fallen and salvaged in 2020 in the SW ¼ Section 19 about 15 metres south of Tree 4 and about 40 metres into the woods from the Paisley Place roadside. It had fallen towards the road unlike Tree 4 raising suspicions that windthrow was not the major common cause of their demise.

Two left-over cuts were investigated, one 21 metres from what had been ground level and another 8 metres from what had been ground level, the wood in-between having been taken away. There was no cut closer to the roots.

The measured circumference with bark at one metre up from the roots was 1.98 m equivalent to a diameter without bark of around 58.4 cm.

Tree 5 Cut 1

At 21.3 m (70 ft.) high, its diameter without bark was 35.7 cm. The rings were in relatively poor shape due in part to the coarseness of the chain-saw so some mis-counting is to be expected. Not knowing the age of the tree at this height, the only dating method possible was to construct a ring-

pattern and try to match it with other trees. The BC Forestry Handbook suggests around 40 years for 70 ft. coastal Douglas-fir, and there are trees in an area in the 707 CP logged in 1956 that were measured in 2019 as being 110 ft (35 m) tall.

The best match that could be found with its neighbour Tree 4 indicated an age range of 1960–2003, but the count was not easy and the match was not completely convincing. Allowing for 40 years of growth prior to the pith date puts its age at the “standard” cut height of one metre at $(2003-1960)+40-12 = 71$ years implying a “date of birth” *circa* 1920, but, as I say this is prone to error. Why such an apparently healthy tree appeared to have ceased to grow after 2003 was a mystery only solved after looking at Cut 2.

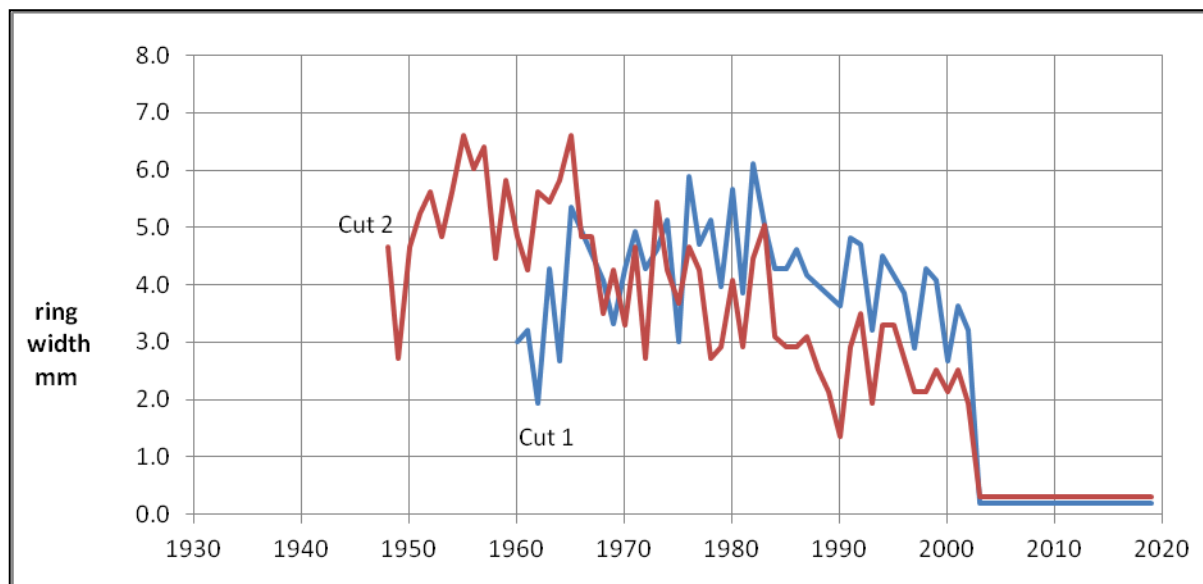
Tree 5 Cut 2

At 8 m (26 ft.) high, its diameter without bark was around 43.8 cm. The BC Forestry Handbook suggests 20 years for 25 ft. coastal Douglas-fir, and there are trees in an area in the 707 CP logged in 1998 that were measured in 2019 as being 27 ft tall.



The rings were easier to identify than in Cut 1.

The analysis indicated an age range of 1947–2003 not including the 5 mm



band immediately beneath the bark. Allowing for 20 years of growth prior to the pith date puts its age at the “standard” cut height of one metre at $56+20-12 = 64$ years implying a “date of birth” *circa* 1927.

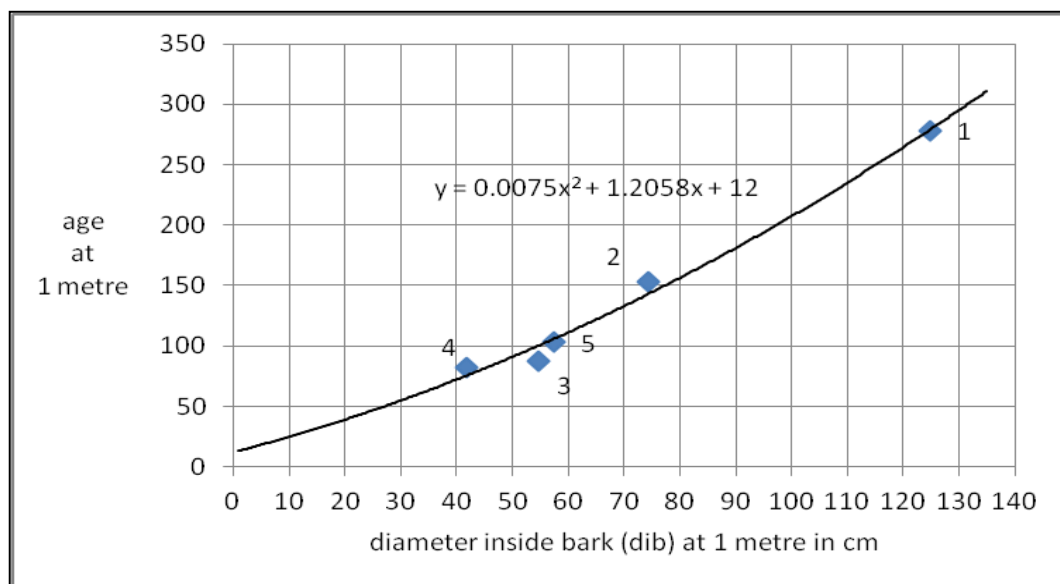
A much closer look at the band immediately beneath the bark showed that this band was not a single ring as had previously been supposed and as it had appeared in Cut 1. Sometime around 2003 something traumatic had happened to the tree.⁴ All subsequent rings were very thin and

⁴ No sign of fire damage. Most roots seemed severed but not all. There was a “twin” tree slightly smaller. The space between the co dominant stems when standing would have only been a metre, so conceivably their root masses had been connected. There were many little piles of boring dust in bark crevices on the downed bole but the beetles creating them may only be taking advantage of a tree already damaged.

tightly packed, and there were enough of them to indicate that the tree was actually still alive in 2020 although growth in its last 17 years growth had been severely stunted, a pattern not observed in other trees.

Tree 5 Cuts 1 and 2

The estimates for the date the tree was at the “standard” cut height of one metre should be the same in the two cases but are not. For Cut 1 the estimate is 1932 and Cut 2 is 1939. The error may well lie in the assumptions for the height:age relationship which varies strongly on growing conditions. Based solely on the three diameters actually measured, linear interpolation indicates the date the tree reached one metre as 1924. A similar analysis based solely on height cannot be done because the relationship between height and age is too non-linear. A “date of birth” *circa* 1912 makes sense given that Tree 5 was larger than the neighbouring Tree 4. ◇



Summary

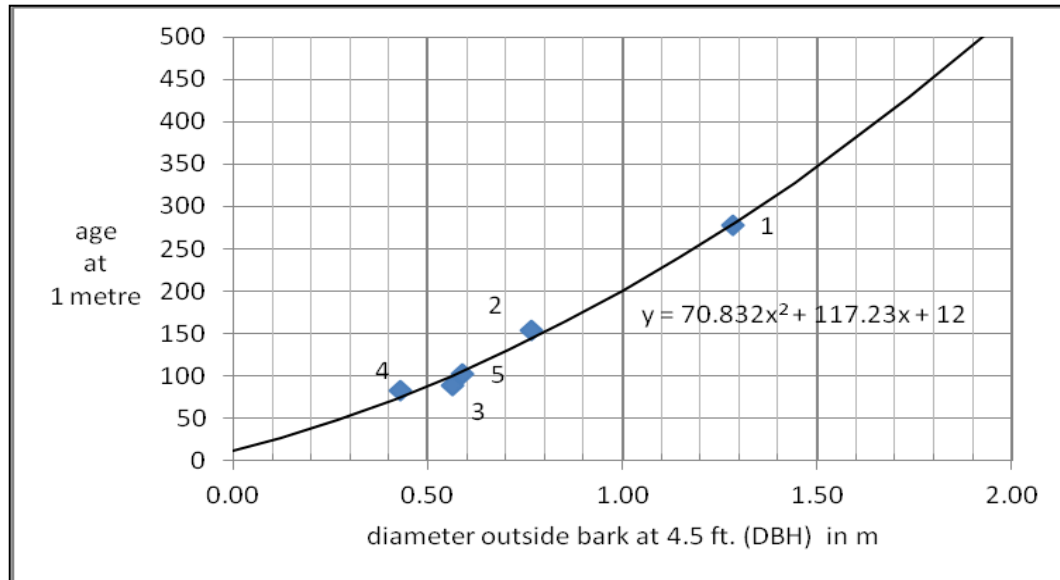
For chain-saw cuts: x-axis = average diameter of cut in cm not including the bark. The cut height when needed but not known is taken to be one metre assuming of course it was not cut by hand with spring boards.

For living trees: x-axis = either diameter incl. bark in cm at one metre height divided by 1.08, or circumference incl. bark at one metre height in cm divided by $(1.08 \times \pi = 3.39)$.

y-axis = age since being one metre high. The age since birth is taken as being *circa* $(y + 12)$.

$$y = 0.0075x^2 + 1.2058x + 12$$

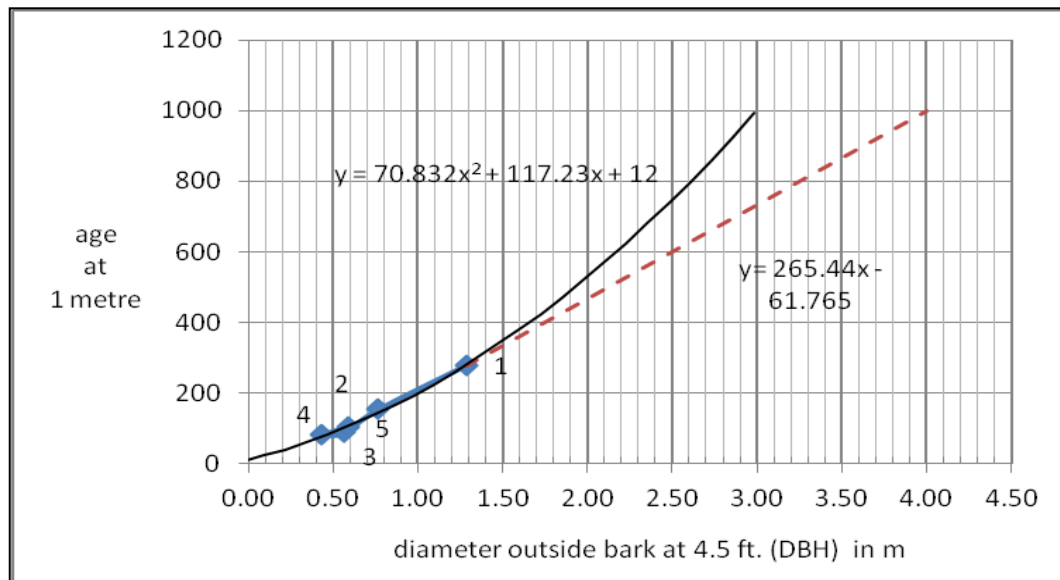
If only DBH or circumference at breast height ($\pi \times \text{DBH} = 3.14 \text{ DBH}$) is available use the next chart using the same basic data but with DBH in metres. The conversion assumes DBH is 1.05 less than the diameter at the chain-saw cut height because BH is higher up the tree, and 1.08 more because DBH includes bark.



$$y = 70.8325x^2 + 117.23x + 12$$

Big trees

The MS Excel trendline in these graphs is a 2nd-order polynomial, but this is undoubtedly an approximation valid for only relatively small trees that have been measured. Nevertheless, what this trendline predicts for larger trees is interesting even if there is little to no hard data on the age:diameter relationship for large Douglas-firs growing on the Gulf Islands or the CDF Biogeoclimatic Zone in general that I can find.



The 2nd-order polynomial trendline predicts a 1000 year old tree on Gabriola would have a DBH of around 3 metres. No trees this big are known, as far as I know. The largest standing Douglas-fir (GaLTT Big Tree Registry #10) is 2.16 metres in diameter giving it a predicted age very close to 600 years.

The largest trees on the west coast of Vancouver Island near Port Renfrew are around four metres in diameter and are commonly held to be a thousand years or slightly more in age. This is shown by the linear extension of the trendline. By this relationship, Gabriola's tree would be almost a century younger at 512 years old. There is however good reason to be suspicious about using the west coast of Vancouver Island as a calibration if only in that summer rainfall there is around 442 mm on average compared to Gabriola's 241 mm, and as shown earlier growth rates are strongly related to summer precipitation.

In general, a linear relationship between age and diameter is not unreasonable for the west coast given that "historical records document some Douglas-firs over 120 metres (400 feet) tall" while the current Red Creek champion is only 74 metres tall. There is lots of potential to push the age limit beyond a thousand years. Similarly I would submit, a quadratic relationship is not unreasonable for the Gulf Islands given that growing conditions are not nearly so advantageous as on the west coast and a slowing down of growth rate with age resulting in a steepening of the age: growth trendline if ever found to be true would not be a surprise.

Small trees

The 2nd-order polynomial works fine for smaller trees. I measured an average dib of 30.5 cm on a 2019 chain-saw cut at the Stanley Place entrance to the 707 CP,⁵ which the polynomial says is 56 rings. I counted 60. The area was logged *circa* 1956. Good enough. Beats wrestling with an increment borer, or worse, waiting for a chain-saw. ◇



⁵ Delamination along annual rings can be a symptom of laminated root rot (*Phellinus weirii*) which is often fatal. Perhaps a reason for this tree having been felled.