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Documenting the Rate of Carving Loss Due to Natural Processes in the Totem Poles of Nan Sdins using Image Analysis – 1982 to 2009

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This paper summarizes field work undertaken at Nan Sdins World Heritage site on Haida Gwaii, British Columbia in the summer of 2009 to assess the changes that had taken place in totem poles since an earlier study by the authors in 1982. The progressive loss of carved image on the poles was assessed by comparing photographs over time. Digital images were modified using off-the-shelf software to remove backgrounds and match the size of the poles. Carved relief loss was estimated by counting pixels and comparing successive losses in images taken over several years. Two of the poles on the site are used as examples of this photographic technique to compare current condition with that predicted by the 1982 assessments of loss in cross-section and extent of interior rot. In a majority of cases this assessment of the interior condition of the poles correctly predicted either an increased loss of carved surface or pole surfaces that remained nearly unchanged. Overall the results clearly show that there is a decrease in the quality of preservation going from the north to the south of the site.

Le présent article résume les travaux sur le terrain exécutés au site du patrimoine mondial Nan Sdins dans l'archipel Haida Gwaii (Colombie-Britannique) à l'été 2009 pour évaluer les changements dans l'état des mâts totémiques depuis une étude menée antérieurement par les auteurs en 1982. La disparition progressive de l'image sculptée dans les mâts a été évaluée en comparant les photographies prises au fil des années. Les images numériques ont été modifiées à l'aide d'un logiciel de série permettant de supprimer l'arrière-plan et de modifier les dimensions des mâts pour les faire correspondre. La perte du relief sculpté a été estimée par comptage des pixels et par comparaison des pertes sur des images successives prises sur plusieurs années. Du nombre de mâts totémiques sur le site, deux sont utilisés comme exemples de cette technique photographique pour comparer l'état actuel des mâts par rapport à ce qui avait été prédit dans les évaluations, réalisées en 1982, de la perte mesurée en coupe transversale et de l'ampleur de la pourriture interne. Dans la plupart des cas, l'évaluation de l'état interne des mâts avait permis de réaliser des prévisions correctes; on a observé une perte accrue de la surface sculptée ou les surfaces des mâts sont demeurées à peu près inchangées. Dans l'ensemble, les résultats indiquent clairement qu'il y a une diminution de la qualité de la préservation, du nord au sud du site.

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Introduction

Ninstints (Nan Sdins) or SGang Gwaay Llnaagay on Anthony Island, in the southernmost part of Gwaii Haanas, was declared a UNESCO World Heritage Site in 1981. This Haida village, on the eastern side of the island, is the best preserved example of a traditional Northwest Coast First Nations village, complete with standing totem poles and the remains of longhouses. In 1982, scientists from the Canadian Conservation Institute (CCI) conducted non-destructive evaluation of the remaining standing totem poles. Twenty-seven years later, in 2009, CCI returned to the site in response to a request from the Haida community to assess whether that evaluation had reliably predicted the process of deterioration.

Evaluation of the Totem Poles in 1982

In response to the UNESCO designation, the British Columbia Provincial Museum (now the Royal British Columbia Museum) requested an assessment of the totem poles on the Nan Sdins site as part of its annual field work program in 1982.[1] Most of the poles on the site are mortuary poles of western redcedar, about 5 metres tall with a diameter of about 1 metre. They were placed in the ground inverted and originally held coffin boxes in hollowed out cavities at the top. As the boards covering these cavities fell away with time, wood rotting fungi and seedlings developed in the exposed cavities. There had been a debate as to whether the level of decay in the wood had reached the point where there was a danger of the poles blowing over. CCI was thus asked to comment upon the structural condition at the base of the poles. CCI scientists David Grattan, Wilf Bokman and Clifford Cook commenced a program of study of all accessible techniques of non-destructive evaluation of wooden objects such as poles with the object of finding out which techniques were likely to be viable in field use.

Based on this evaluation, four principal techniques were adopted. These were:

- 6J Pilodyn measurements,[2]
- digitally interpreted conventional radiography of the base of a pole,
- probing with a sharpened steel rod at ground level, and
- moisture measurement with a resistance type meter.

Applied to the base of the pole, these techniques were able to give (a) a measure of physical strength of wood at the pole surface less than a metre above the ground, (b) an estimate of the overall state and the location of any major loss in the first half meter of the pole above ground, (c) the intrusion of rot at the ground-air interface and the reduced cross section at the base, and (d) the moisture content of the pole and the moisture profile of the pole surface above ground. In early tests, we discovered that we could not interpret radiographic data in a straightforward fashion by direct visual interpretation. We therefore developed a digital method which employed measuring the silver image density on the x-ray film to estimate the residual wood present and hence calculate the average density of residual wood substance.

Tests were completed on 25 poles at the site. We photographed the base of the pole, evaluated the residual intact cross section at ground level (based on probing), conducted radiographic analysis at one to four cross-sections, and took Pilodyn and moisture content measurements. Transparent polyethylene sheeting (ca. 1 metre wide) wrapped around each pole near ground level was used to record the location of each measurement and was useful in later laboratory reconstruction of the geometry of the readings. Both black and white and colour photography were used to document condition. Not much consideration to was given to the retention of carved relief and hence the retention of meaning. On consideration of the measured condition of the wood and of the effect of wind pressure, CCI concluded that the poles were in little danger of blowing down: "absolute strength was not a serious concern for most poles" because "Ninstints mortuary poles are wide in section relative to their height and would have to lose a tremendous amount of strength before being in danger of blowing over."[3] The results of this testing were presented and evaluated for each pole individually in a report, "Non Destructive Examination of Totem Poles at Ninstints Village Skung-Gwaii (Anthony Is.) Queen Charlotte Is. B.C."[4] This report was summarized in a publication.[5]

Re-evaluation in 2009

In 2007, while attending a special conference on totem poles in the Haida Heritage Centre at K̲ay Llnagaay, David Grattan was fortunate to encounter Patrick Bartier of the Parks Canada Office in Skidegate. Bartier had carefully archived all the available documentation of the Nan Sdins site, including all original CCI research data, radiographs and tracings from 1982. Grattan also met with Captain Gold and Barbara Wilson, members of the Haida community and former Watchmen, to discuss the usefulness of a possible return visit to Nan Sdins by a CCI crew. The data from 1982 could be considered as a useful baseline that would allow two lines of enquiry regarding the deterioration of the totem poles:

(1) What changes had taken place in the 27 years that had elapsed since the original study?

(2) How well did the 1982 radiographic survey predict the pattern and progress of deterioration?

The Haida supported the idea of further assessment and wondered in particular if the lifetime of the remaining standing poles could be estimated.

Evaluation of the totem poles using the same techniques employed in 1982 was not possible, however. The 2009 research permit authorized CCI to "conduct a non-destructive evaluation of whether the 1982 study of the condition of the totem poles at Nan Sdins provided a reliable indication of the condition of the poles today".[6] "Non-destructive" in 2009 meant that the poles could not be touched; therefore we could not repeat the Pilodyn and moisture measurements, the radiography or the probing that we had been able to do in the 1982 survey. However, we would be able to document the outward appearance and evaluate whether there was any correlation with the observations and conclusions from the earlier report.

With this in mind we decided to bring as much expertise as possible into the field to evaluate the superficial condition of the wood and to discuss changes that had evidently taken place in the period from 1982 to 2009. In 1982 we had focussed much attention on the pole bases where radiography and probing were conducted. We traced the pole surfaces in this base region on polyethylene sheeting to record features and the location of test points and we photographed the base of each pole from all four sides. Our intention in 2009 was to repeat the photography of the bases, update the tracings and measure any changes. In practice – even though all photographs were repeated and copies of the original surface tracings were taken into the field – this approach yielded little information of value. It was almost impossible to measure any changes because of the difficulties inherent in relocating the tracings precisely. Some of the poles had been straightened and placed deeper in the ground; for this project there was no archaeological excavation around the bases of the poles to expose more of the wood. Moreover, we were also restricted from placing anything on the carved front surfaces of the poles.

Given these challenges and restrictions, we adopted a different approach to evaluate the poles. Rather than focus on the base of the poles, we conducted a systematic comparison of photographs of the complete carved front of the poles taken in 2009 with those taken earlier. In order to make the changes obvious and measurable, we developed a technique in which missing surface details or surface changes were identified in red on images of the poles over time. By mapping where the decay occurred over time in this way, we were able to visualize the degradation process and how rapidly it progressed.

Assessing Totem Pole Decay Using Image Analysis

Change over time was assessed through visual comparison of the front of the totem poles at Nan Sdins as recorded in photographic images. In addition to photographs taken during the 1982 and 2009 site assessments, we accessed and scanned as many early photographs as possible to see how deterioration progressed through time. While in Haida Gwaii, we were able to take advantage of the photographic documentation held in the Parks Canada Agency archive under the care of Patrick Bartier. These photographic records contain images of poles taken in earlier years so that it is sometimes possible to see detailed changes on the surface as they progress slowly over the course of up to a century.

Image Correction

Because the images used were not taken under standard conditions, they needed some correction prior to comparison. Using various tools in Adobe Photoshop Elements 5, we isolated the pole images by cropping and erasing the surrounding backgrounds, re-sized each to match them with one another by lining up carved features in the separate images, and vertically aligned them.

Loss Calculation

The percentage loss of carved relief due to decay was estimated for each photograph by counting image pixels in Photoshop Elements. Using the pencil tool, the carved area of the pole in each corrected image was outlined in black and areas of loss were outlined and coloured red. The Magic Wand tool was then used to select the area within the black outline but excluding the red areas. The number of pixels in this selection was displayed in the lower left of the Histogram window that is activated by clicking on Window – Histogram. With the Magic Wand tool still selected, each red area was added to the total selection by right clicking and choosing to add it. The number of pixels displayed increased to include the red areas. It was a simple matter to calculate the amount of loss as a percentage of red pixels to the total pixels in the image area. Small differences in image resolution were not important because the pixel counts were not compared between images. Since the focus of this study was on loss of carved front surfaces that are the historically important parts of the poles, the backs of the poles, which generally are not carved, were not analysed.

Results

Surface Loss

The percent residual carved relief in 1982 and 2009 is compared for each pole in **Figure 1** and **Table I**. Three of the poles (2, 5 and 10) have suffered no surface losses and still retain 100% of the carved features. All of the others for which carved areas were documented in 1982 show an increased loss of carved image since then. We present in detail below the results from two poles, poles 1 and 9, which exemplify some of the trends. Note that some poles are missing entirely because they have fallen over and have little or no image remaining. It should also be noted that poles 21, 23 and 25 show evidence of being burnt in an 1892 fire;[7] as a result, the little remaining image was not documented in 1982.

The data in **Table I** show that in 2009 one third of the poles still retain more than 80% of their carved relief, only one fewer than did so in 1982. Altogether the surviving poles preserve about 44% of their original surface carved relief, an overall loss of about 5% of carved relief since 1982. Generally speaking, there is a noticeable decrease in the quality of preservation going from the north (pole 1) to the south (pole 25) of the site. This shows up well in the plot shown in **Figure 1**. A comprehensive report[8] on the 2009 re-evaluation compared loss analysis results with original 1982 data for each pole.

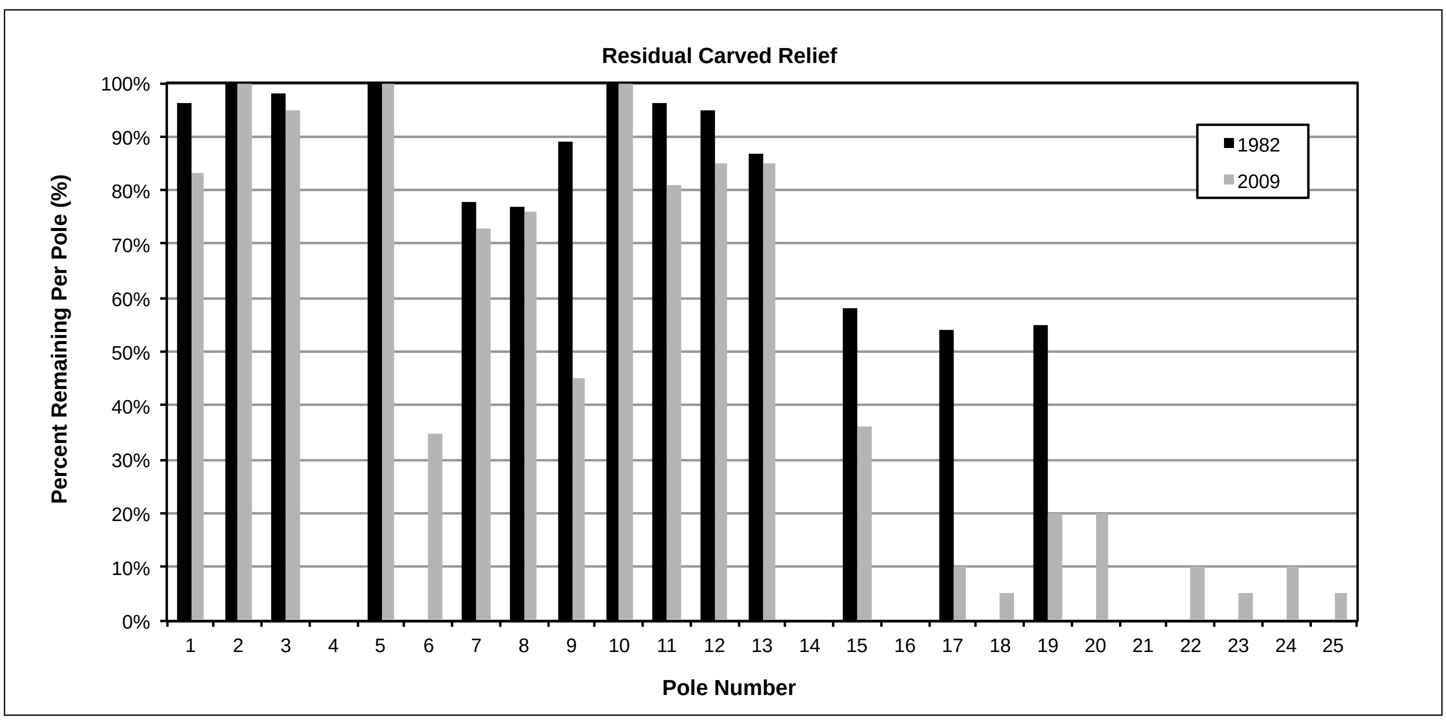

Figure 1. Comparison of percent residual original surface (i.e. carved relief) for 1982 and 2009 by pole number going from north to south across the site.

Table I. Summary of Pole Condition.

Pole Number		% Residual Surface				
Florian et al[1] Grattan et al[3]	**MacDonald[9]***	**1982****	**2009**	**Prediction 1982 – Outcome 2009*****	**Upright in 1982?**	**Notes**
1	18X	96%	83%	stable	yes	
2	17X	100%	100%	stable	yes	
3	16X3	98%	95%	~~loss~~	yes	
4	16X2	(no data)	0%	(not radiographed)	yes	small fragment, no carved area
5	16X1	100%	100%	stable	yes	
6	15X2	35%	35%	(not radiographed)	yes	fragment of pole
7	15X1	78%	73%	~~loss~~	yes	
8	14X2	77%	76%	~~loss~~	yes	
9	14X1	89%	45%	loss	yes	
10	13X2	100%	100%	stable	yes	
11	13X1	96%	81%	loss	yes	
12	11X	95%	85%	~~loss~~	yes	
13	10X	87%	85%	stable	yes	
14	9X	(no data)	0%	(not radiographed)	no	pole overgrown
15	9M1	58%	36%	loss	yes	
16	8X	(no data)	0%	(not radiographed)	no	pole overgrown
17	7X2	54%	10%	loss	no	
18	7X1	(no data)	5%	(not radiographed)	no	
19	6M	55%	20%	~~stable~~	yes	
20	6X	(no data)	20%	(not radiographed)	yes	fragment of pole
21	5X4	(no data)	0%	loss	yes	fire damage, no carved area
22	5X1	(no data)	10%	(not radiographed)	yes	fragment of pole
23	5X2	(no data)	5%	~~loss~~	yes	fire damage
24	2X2	(no data)	10%	loss	yes	
25	2X1	(no data)	5%	~~loss~~	yes	fire damage

*MacDonald uses M to denote a memorial pole and X to indicate a mortuary pole. The first number is the house the pole is associated with and the second number is pole number for that house. For example house 16 has three mortuary poles associated with it.

**The data missing for 1982 are generally for poles that had significant losses in 1982 and it was believed at the time that there was little or no risk of them blowing over so a complete analysis was not done. The goal of the work in 1982 was to evaluate the strength of the base of the poles and as a result the carved areas of the poles were not fully documented in all cases.

***The prediction regarding pole condition (stable or loss expected) is based on the results from the 1982 radiography and whether it was confirmed or not (strikethrough) in 2009. In 1982, radiography was the only technique based on our evaluation that indicated an internal loss of structure in the poles that could be used to predict future losses.

Pole 1

Pole 1 had changed very little in overall appearance since 1982 and still looked much like it did in 1957, as is clear from the comparison shown in **Figure 2**. Note, however, that after 1957 the last frontal board was lost and by 1994 the coffin box in the recess at the top of the pole had disappeared. The slow rate of surface change correlates well with the observations made in 1982 which showed little bulk degradation of the lower portion of this pole. **Figure 3** shows the radiographic wood density at 5 and 22 cm above the ground as measured in 1982. Note the close correlation between measured wood density (continuous line) and normal density of western redcedar (0.34 g/cc, dashed line). 6J Pilodyn data (**Figure 4**) indicated that the density of the superficial wood at about 20-30 cm above ground was between 0.30 g/cc and 0.36 g/cc – within the range of the normal density for western redcedar. At ground level, the values are somewhat less as a result of deterioration. In addition, the probing results around the base of the pole (**Figure 5**) showed comparatively little loss of cross section to rot.

When the surface of Pole 1 was re-examined closely in 2009, however, it became clear that significant changes had taken place and that the appearance of little deterioration or of stability will likely soon change. The pole appeared seriously rotted below a white/light grey shell on the surface. In some areas the sound surface zone was perilously thin and had an almost lace-like quality. While surface losses are generally small, crack propagation and the growth of pockets of rot are evident. These changes become more prominent when the surface losses are marked in red (**Figure 6**) and the progression from 96% to 83% carved image remaining can be seen.

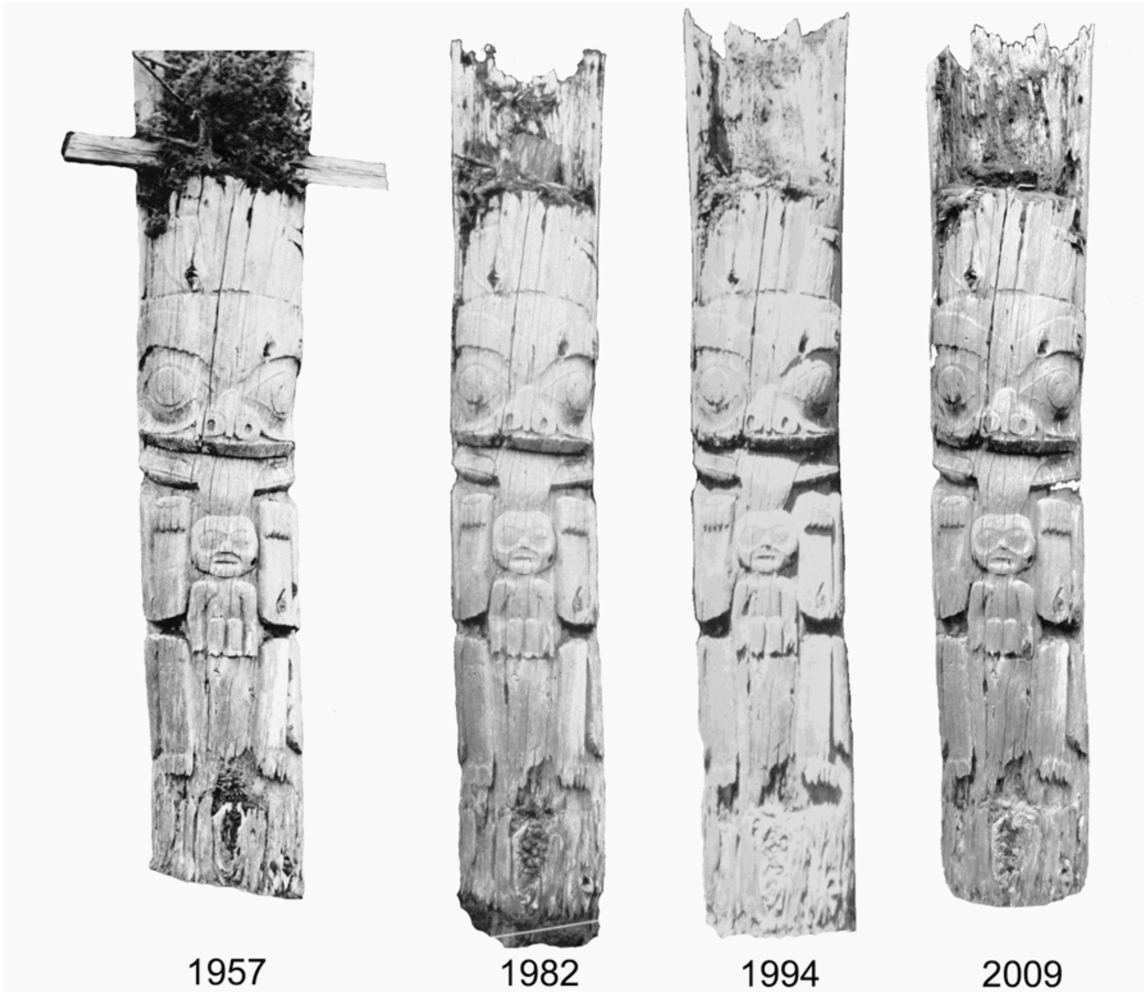

Figure 2. The changing appearance of pole 1 from 1957 to 2009. Notice the loss of the coffin box between 1982 and 1994. Image from 1994 photograph courtesy of Gwaii Haanas/Parks Canada. Image from 1957 photograph, PN07672, courtesy of Royal BC Museum, BC Archives. Images have been cropped from the original photographs.

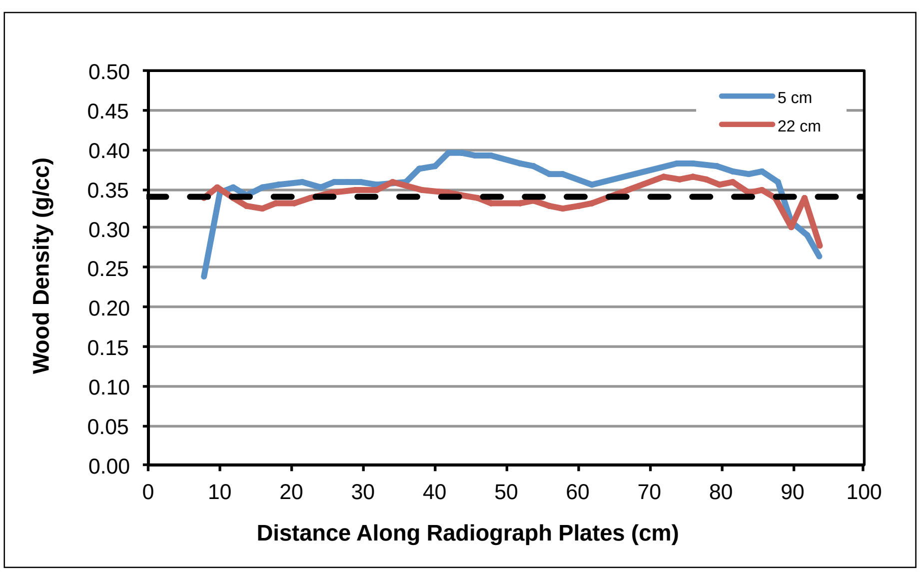

Figure 3. Radiographic wood density of pole 1 at 5 and 22 cm above the ground in 1982. The dashed line is the normal density of western redcedar.

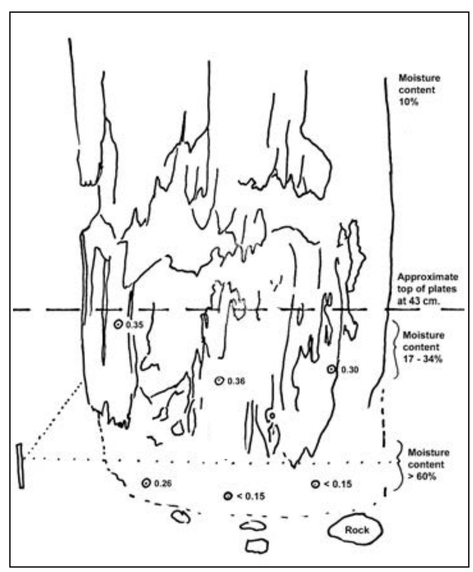

Figure 4. Pilodyn measurements of the front of pole 1 at the base in 1982.

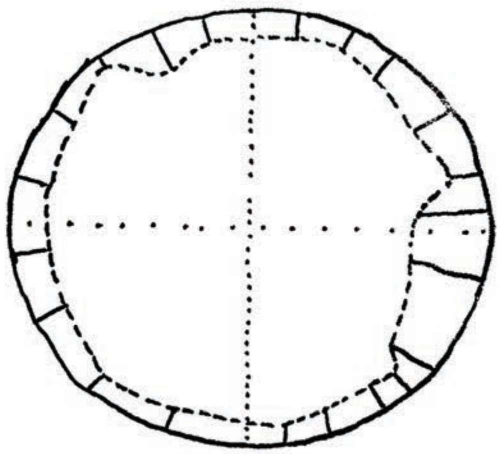

Figure 5. Apparent sound cross section (inside dashed line) at the base of pole 1 as measured by probing at ground level in 1982. The diagram shows that 71% of the total cross section of the pole was remaining.

Pole 9

Pole 9 provides an interesting example of extreme deterioration (**Figure 7**). The data accumulated in 1982, which are shown in **Figures 8** and **9**, clearly indicated that the left (right proper) side of the pole was seriously deteriorated, although perhaps not so much at ground level. Moving up the pole from a height of 5 cm to 39 cm, the radiographically derived density – shown as the continuous lines in **Figure 8** – diverged from the normal western redcedar density of 0.34 (the dashed line) on the left side of the graph. Nevertheless, little surface damage was evident in 1982 (**Figure 7**). However, as the photograph taken in 2009 shows, major losses on the left side, including substantial surface carving, have exposed the inner deterioration indicated radiographically in 1982.

Figure 10 highlights the losses that occurred between 1982 and 2009. The percent carved image remaining dropped from 89% to 45%. The source of these losses is abundantly clear: extensive interior rot likely augmented by the presence of a massive root system from a tree that grew on the top of the pole. As with many of the poles, vegetation grew in the

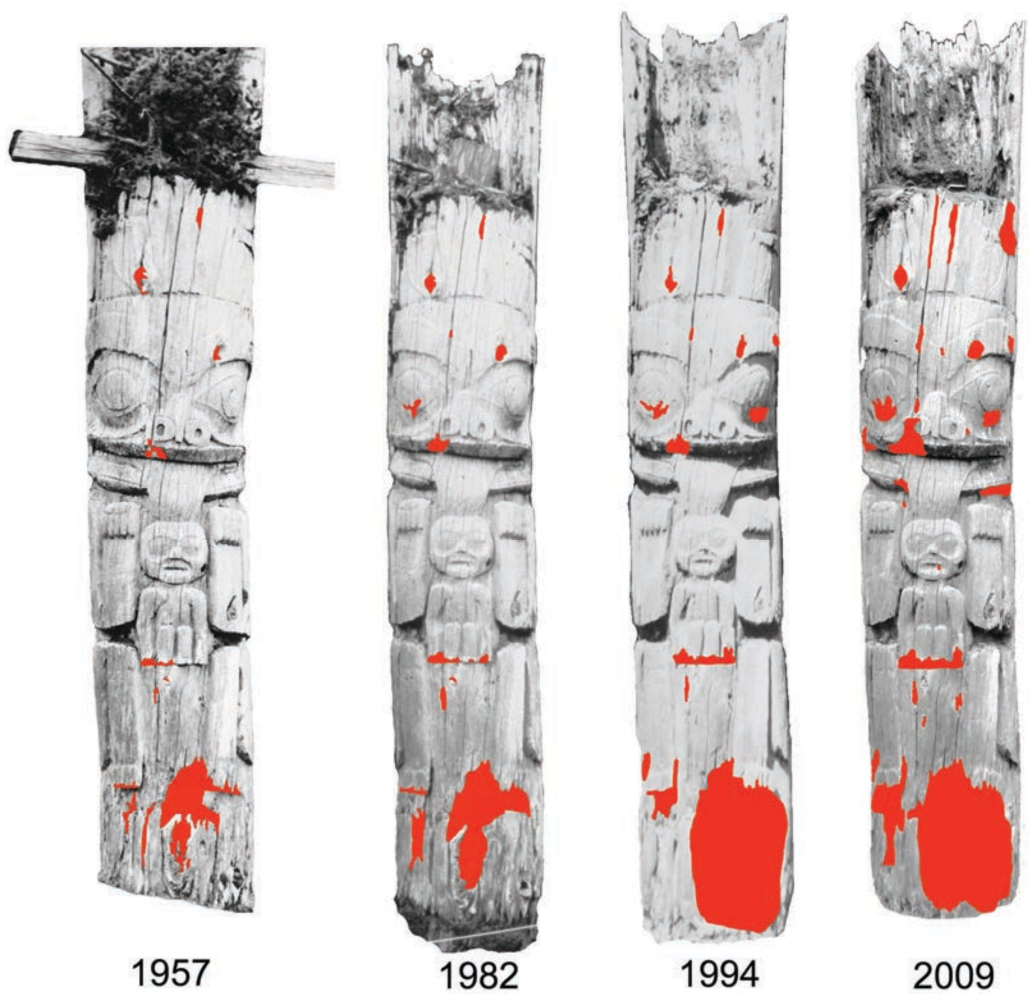

Figure 6. Carved relief loss in pole 1 from 1957 to 2009 marked in red on corrected images. Image from 1994 photograph courtesy of Gwaii Haanas/Parks Canada. Image from 1957 photograph, PN07672, courtesy of Royal BC Museum, BC Archives. Images have been cropped from the original photographs.

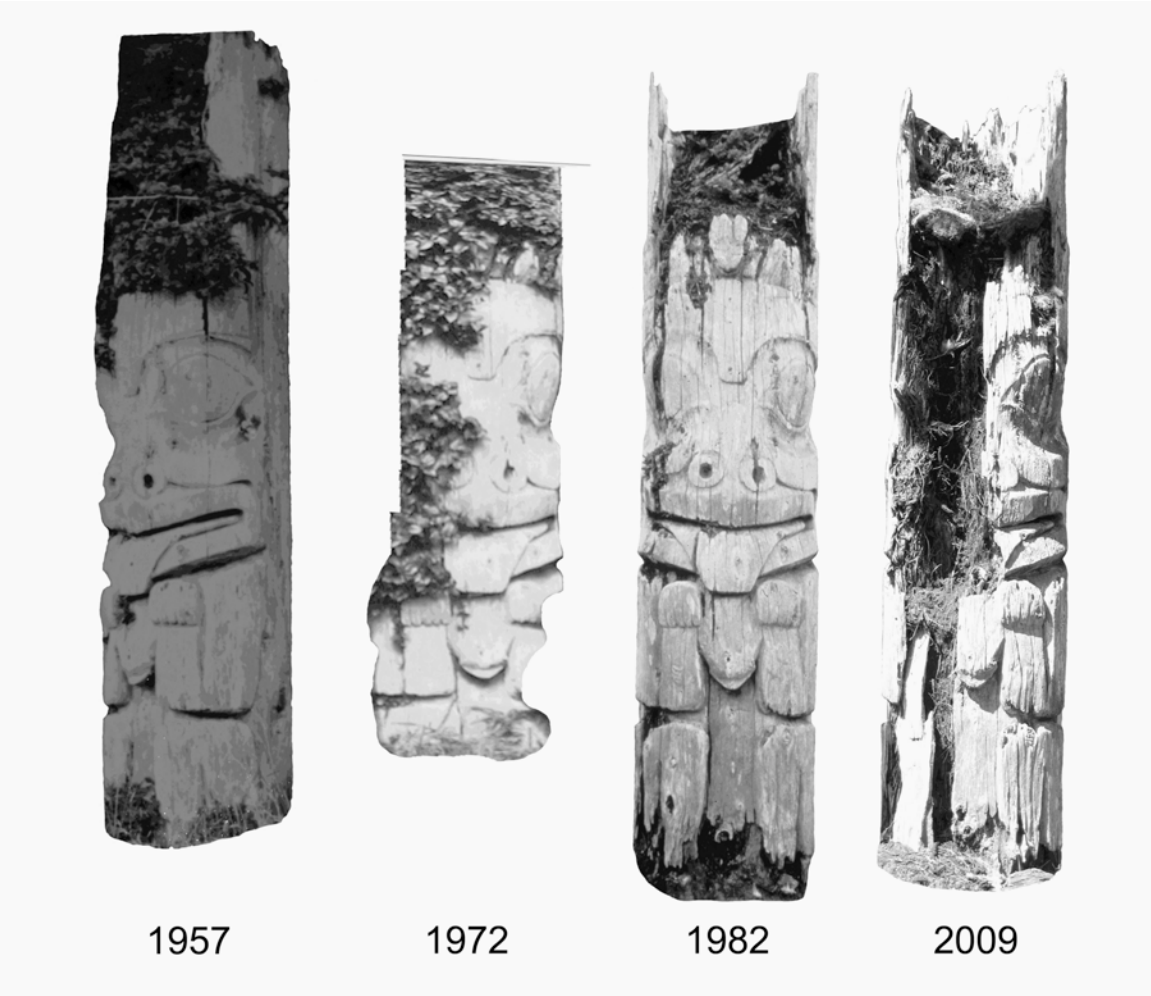

Figure 7. Pole 9 from 1957 to 2009. Images from 1957 and 1972 photographs courtesy of Gwaii Haanas/ Parks Canada.

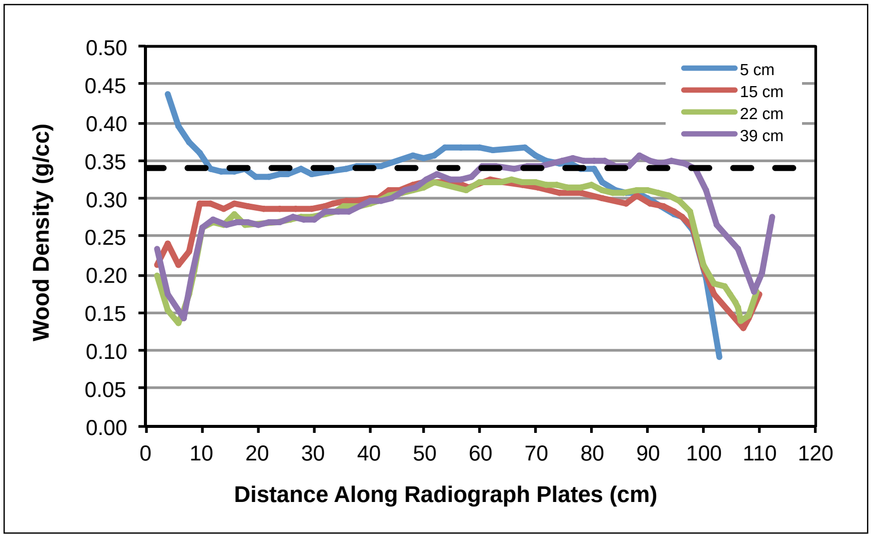

Figure 8. Radiographic wood density of pole 9 at 5, 15, 22 and 39 cm above the ground in 1982. The dashed line is the normal density of western redcedar.

coffin recess at the top and in this case pushed its root system down through the pole. The roots undermined and dislodged the surface on the right proper side. Although the quality of the earlier images (pre 1982 in **Figure 7**) is very poor, making precision difficult, it does appear that very little if any rot had shown itself on the surface of the pole before 1982. This is also a good example of how changes in the appearance of poles can be sudden and catastrophic.

Reliability of Predictions based on Wood Condition

The reliability of the 1982 condition assessment for predicting loss is also indicated in **Table I**. Predictions for either continued stability (sound interior wood condition in 1982) or loss (poor interior wood condition in 1982) were correct for 11 of 18 poles radiographed in 1982. By 2009, predicted loss had not yet occurred in 6 of 12 cases and in only one case (pole 19) did the extent of loss

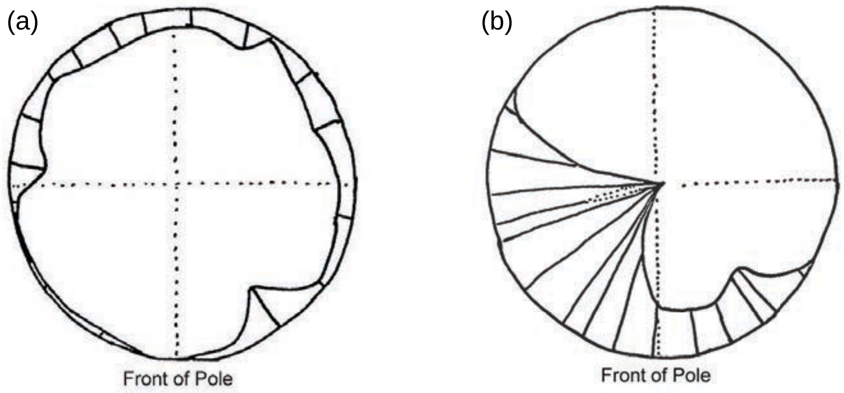

Figure 9. Apparent sound cross section (inside dashed line) of pole 9 at (a) ground level and at (b) 30 cm above ground level as measured by probing in 1982. The diagram shows the extent of loss higher in the pole: 83% of the total cross section of the pole remained at ground level but only 64% remained at 30 cm above ground level.

Prediction of surface retention or loss based on interior wood condition was reliable for about two thirds of the poles. Examples of correctly predicted stable condition and predicted loss have been described. When pole 1 was examined in 1982 it showed few signs of bulk deterioration as indicated by the density measurement by radiography and Pilodyn in **Figures 3** and **4**. An examination of the surface in 2009 showed very little additional loss of carved image as shown in **Figure 6**. On the other hand, pole 9 had a completely intact surface in 1982, but radiography revealed that the interior was seriously compromised on the right proper side (**Figure 8**). By 2009 the surface on this side of the pole had broken away completely, revealing a soft pulpy rotten interior with exceed what was predicted, with the loss of carved relief on the left side of the pole. Of the 25 poles on the site, seven were not radiographed in 1982. Of the 15 poles with image loss data from 1982 for which comparison of image loss was possible in 2009, predictions were accurate in 9 cases (almost two thirds) even though the 1982 testing was not intended to predict surface carving loss.

Discussion

This work has provided some new information on the decay rate of the Nan Sdins poles. Deterioration has been a relatively slow process in the decay-resistant cedar in the temperate wet rainforest conditions of Haida Gwaii. The poles are remarkably durable having most likely been erected between 1800 and 1864 as indicated by dendrochronological dating done by the Royal British Columbia Museum.[10] After 150 to 200 years, eight poles still retain over 80% of surface carving, ten poles over 75%. In 2009, eight of the poles exhibited less than 5% additional surface loss compared to 1982, half these essentially none.

The original intent of this survey was to measure the predictive capacity of the radiographic procedure by characterizing the surface condition of the poles 27 years after the 1982 study. That earlier study had one well defined goal: to determine if the standing poles were at risk of being blown over as a result of the deterioration at ground level. To this end, probing the bases with a steel rod to determine loss of thickness, measuring surface wood density with the Pilodyn and radiographing the lowest 40 or 50 cm provided a well-documented answer of no. The 2009 survey confirmed the accuracy of this prediction: no further poles have fallen over. However, in some instances radiography showed losses in wood density for particular poles that were not apparent with a visual examination of the pole exterior. This suggested that a degradation of the interior of these poles had occurred leaving a more fragile exterior shell. Although this might not result in the poles falling over, it would eventually result in surface loss.

Figure 10. Pole 9 in 1982 and 2009 with the losses indicated in red.

evidence of massive root invasion and humus formation (**Figures 7** and **10**). The debris from the pole was lying on the ground which would suggest that this loss was not a result of vandalism.

Nevertheless, other poles (3, 7, 8, 12, 23 and 25) in which equally dramatic losses were predicted by radiography have not yet exhibited visible physical losses. This is about one third of the standing poles that were radiographed and is most likely a reflection of the limitations of the technique in that it does not identify loss precisely in three dimensions. In this near-final stage of the decay process, the sculpted surface is often shed as a sheet of wood of thickness 5-8 cm, shorn off along the grain from an incipient crack. These kinds of details of deterioration are too fine to identify through radiography.

Imprecise prediction may also result from the number of processes that contribute to the ongoing deterioration of totem poles which have different rates of decay over time.[11] Fungi and bacteria attack the wood directly and the pole deterioration is increased by brown, white and soft rot. In the wet coastal climate, existing rot pockets continue to spread because of the continuing ingress and egress of moisture. The clearing of vegetation on the site during the early 1980s has likely resulted in conditions similar to those when the poles were erected. However, we have no data to indicate changing moisture contents in the poles that might slow or accelerate continued deterioration. The majority of this deterioration occurs in the interior of the pole and can cause extensive hidden damage before the surface of the pole is lost.

Deterioration is also influenced by mosses and vegetation that grow on the exterior of poles. The mosses do not attack the wood but retain surface moisture and provide areas where other plants can take root. Vegetation, such as trees and bushes, sends roots into the interior of the poles and causes extensive damage by splitting the pole or causing larger pieces to slough off. In other cases, the growth of leafy branches provides something which acts like a sail and the wind pressure resulting causes the pole to be blown over. Pole 17 shown in **Figure 11** is a classic example. The pole had blown over before 1982 and, by 2009, has lost nearly all its carved relief; yet still embedded was a massive parasitic root.

As the interior of the poles degrades, the moisture content rises and the wood can become more susceptible to insect attack. In spite of this trend, a limited examination of the exposed interiors of the poles on the site did not show significant attack by insects. There were a few instances of what might have been flight holes in some of the remaining original surfaces, but no large infestations were seen in those poles where the interior was exposed.

When the interior is in very poor condition, wind could cause whole design elements to separate and fall to the ground. For the last 25 to 30 years there has been a significant change in the environment the poles have experienced. The efforts of museum staff in the early 1980s have pushed back the edge of the forest and exposed the poles to more sunlight and wind. How this environmental change has affected the poles – if it has – is not known. The presence of increased sunlight that might well have dried out the wood, and the heightened exposure to wind could have augmented the surface loses documented in this study. The loss of surface features can also result from physical contact with such highly degraded poles, during maintenance activities such as straightening, for example.

Vandalism can also cause damage but there was no direct evidence that this caused any of the damage observed in this study. However, the images of pole 11 in **Figure 12** show the loss of a face near the bottom sometime before 1975 and in **Figure 2**, the coffin box at the top of pole 1 was not there after 1982. These could be considered as possible examples of unsanctioned removal of material.

The many factors that contribute to pole deterioration through interior decay also point to the limitations of the photographic method used to assess rate of decay in this study. Deterioration below the surface is not assessed by photographs. A pole that is seemingly in good condition may have little internal structure left which could result in unpredicted catastrophic losses. Close observation in 2009 suggests this may now be the case for pole 1 but the photograph in **Figure 2** can only hint at this change. More interventive techniques, such as those used in 1982 (the Pilodyn or radiography) or the Resistograph,[12] can identify internal decay and thus could better predict this risk of imminent large loss. The length of time before such loss occurs is still uncertain, however, as the 2009 observations show: as many predicted losses have not yet occurred as have occurred. More frequent systematic photographic

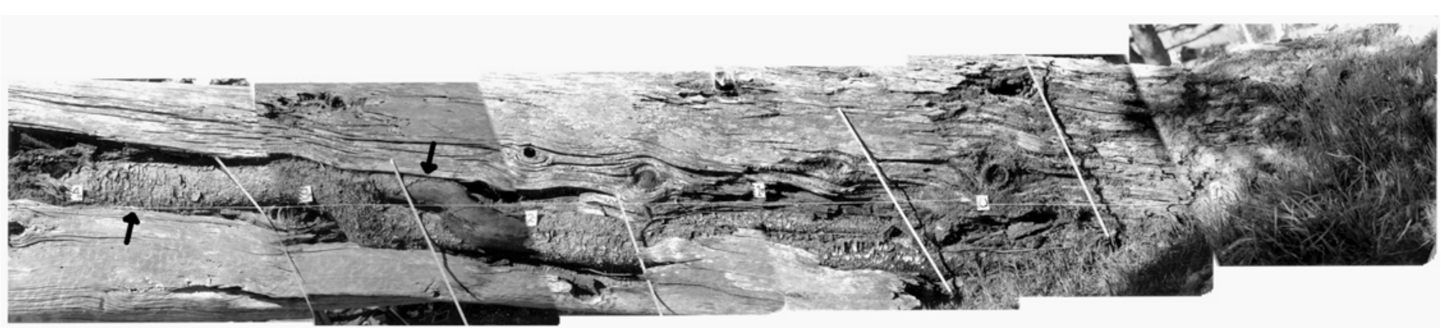

Figure 11. A photo montage of fallen pole 17 in 1982 showing the tree root extending along the length of the pole (the base of the pole is to the right).

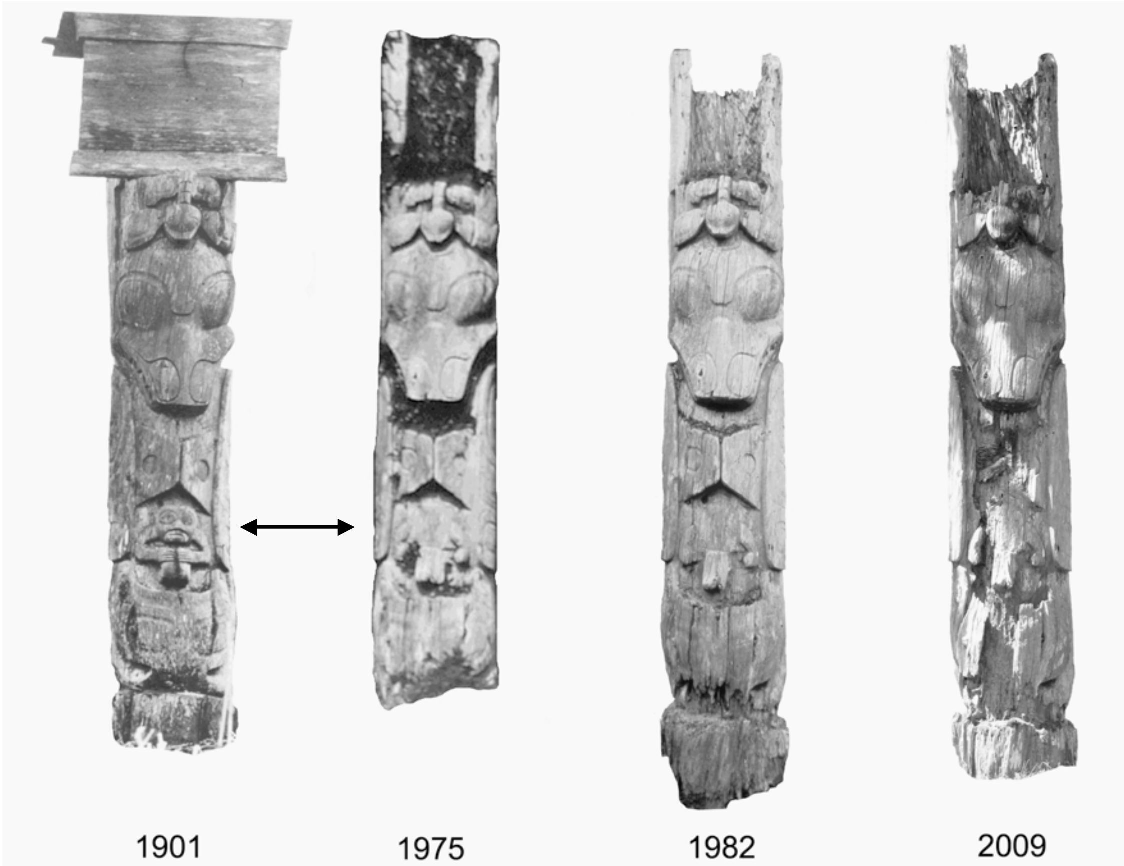

Figure 12. Changes in pole 11 from 1901 to 2009 including losses that might be attributed to vandalism. Image from 1975 photograph courtesy of Gwaii Haanas/Parks Canada. Image from 1901 photograph, PN07781, courtesy of Royal BC Museum, BC Archives. Images have been cropped from the original photographs.

documentation than used for this study – every 20 years, for example – may improve the predictive capacity of photographic documentation, particularly once patterns of total deterioration have been established for older poles. Use of early photographs is not always helpful. We compared images of the poles going back in a few cases to 1901, but often the images did not provide a full frontal view, making them unsuitable for this study. The big advantage of only using photography is that it is completely non-destructive with no physical impact on the poles.

Included in the comprehensive report of the 2009 study was an attempt to estimate the remaining lifetime of the poles as requested by the Haida. The use of plots of residual surface over time to do this is intriguing but inconclusive given the limited data analysed to date. The change in residual carved relief depicted in **Figure 1** clearly shows that the poles at the north end of the site are better preserved than those to the south. This ties in well with the dendrochronological data from 1993[10] which dated the youngest pole (pole 3) to 1864 and the oldest house post near the south end of the site to 1800. Thus erection of structures and poles on the site spans about 65 years. Since few carved images remain on the oldest standing poles, it is conceivable that within the next 65 years there will be very little, if any, carved image remaining on the poles.

Conclusion

Using a completely non-interventive image analysis technique, this study has provided some new information to help describe the decay rate of the Nan Sdins poles. Poles that have survived for over 150 years continue to exhibit slow loss of surface carving in many cases. Where interior decay is advanced, significant loss can occur within a quarter century as indicated by the comparison of 1982 and 2009 data.

This study also assessed the predictive value of the radiography completed in 1982. Analysis of photographs of the poles indicates that the physical changes predicted by radiography in 1982 came to pass by 2009 in two thirds of the cases. More modern methods of determining the interior physical state of poles, such as the Resistograph,[12] may provide better data; however, the radiographic technique is completely non-invasive, which may be an important consideration for certain types of cultural material. Radiography also has the advantage of providing an evaluation of internal condition completely across the base of a pole. In comparison, the drill on the Resistograph penetrates deep into the wood at a single point and so could miss pockets of rot or void spaces. Radiography does have the disadvantage of requiring heavy cumbersome equipment and comes with health and safety regulations that must be met because the equipment is a source of radiation.

This work did confirm that image analysis alone cannot provide direct information on the extent of interior decay. Further systematic work such as a sequence of photographs of a pole taken over several decades would be needed to test its usefulness in predicting the progress of totem pole decay. The limited data available in this study did show that the decay of the poles appeared to progress logarithmically but more photographs of the poles would be needed to generate predictive graphs. When new poles are erected, this simple and inexpensive technique could be used to monitor losses as the poles age.

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12. The Resistograph is a portable device developed in the early 1990s to measure the interior of trees and poles. It functions by measuring the torque required to drive a thin drill into the interior of a wood object like a totem pole. Changes in the interior density and growth ring spacing are recorded as the drill travels into the wood. Zones of decayed wood or voids can be seen in results. For more information see: <http://www.rinntech.de/content/view/8/34/lang,english/>. Accessed April 2014.