Opportunities for incising UK timbers

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Executive Summary

In order for home grown softwood species to operate in Use Class 4 (in ground contact), suitable preservative treatments are required. Traditionally, this would have meant treatment with CCA. Many of the replacement treatments have lower biotoxicity levels to CCA, and require impregnation to a greater depth to ensure similar performance levels. An additional problem then arises, since much of the home grown timber is Sitka spruce, a diffuse porous species, whose cellular structure renders impregnation treatments ineffective, especially once drying has occurred.

This report, outlining the closing report for work undertaken as detailed in Forestry Commission proposal (FG14/04), details work carried out further to a previous Forestry Commission / Scottish Enterprise project (contract agreement PPD29/02), where a new incising pattern was considered.

Results herein discuss the creation of incising equipment using this new cutting pattern, and subsequent assessment of treatment penetration of incised timber. Results following preservation of Sitka spruce showed a considerable increase in preservative uptake and of the overall penetrative depth of treatment. However the results obtained did not reach the levels stipulated within BS 8417 for a 15-year service life. Further tests would be required to assess the resulting service life of incised Sitka spruce compared to the non-incised material.

The concept of incising has been well received across the industry, this being strengthened by a presentation to the Highways Agency. This increased exposure builds on the work undertaken according to contract agreement PPD29/02 and reported in BRE report 214 436. Many of the cost implications previously listed remain in place, though there have been increases in unit prices of electricity. This has probably led to an increase of add-on cost to approximately £8 /m3 after initial set-up costs. This add-on cost accounts from electricity demand of machinery and additional preservative used.

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Contents

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Introduction

Incising timber by creating small slits or pin holes in the surface of the timber to improve uptake and penetration of preservative has long been recognised as an accepted method for improving the durability of timber. Previous BRE trials (Smith and Orsler 1995) and experience from existing international practice have sought to demonstrate the potential for incising timber prior to preservative treatment. Although very small volumes of imported incised timber are used in the UK for applications such as freshwater jetties, incising has decreased in popularity in the UK to the point that no companies are actively engaged in incising timber. This is because the benefits gained from the processing have yet to justify the financial outlay of equipment. One of the key arguments against incising is the reduction in bending strength, with some studies showing reductions in Modulus of Rupture (MOR) of 16% and in Modulus of elasticity (MOE) by 13% (Banks 1973). However, the potential uses of incised timbers can allow for a reduction in mechanical strength, with the benefits gained from the increased durability of the timber from greater preservative uptake providing the key operating parameter. Indeed, the issue of reduction in strength has been overcome by work in the US and Canada, by increasing the cross sectional size of incised timbers by an appropriate amount to compensate for measured losses.

The original BRE work (Smith and Orsler 1995) resulted from a long-term field trial (Hazard Class 4) set up in 1972, using an incising pattern as shown in Figure 1. The results obtained from this showed in-ground performance greatly exceeded traditional expectations, with service lives greater than 30 years.

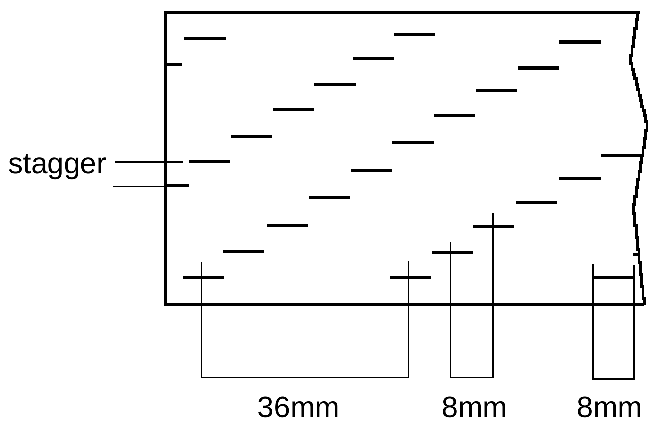

Figure 1: Schematic of incising cutting pattern used to incise UK timbers for national field trials.

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This original trial was undertaken with timber species whose use is normally restricted to Hazard Class 3. Among these species are the commonly grown UK species Sitka spruce, larch and Douglas fir.

Based on this original work, a second project funded by Forestry Commission and Scottish Enterprise (contract agreement PPD29/02) and subsequently reported (McMinn 2004). The main focus of this work was the development of a new incising blade (Figure 2). Altering the pitch of leeward side of the blade could alter the degree of 'plucking' of fibres from the main body of the timber. This would give the combined effort of surface puncturing and lifting of remaining fibres on the incised surfaces.

Figure 2: New incising blade pattern used in BRE trials.

With parallel orientation of these blades within the incising apparatus, a more uniform incising pattern could be achieved (Figure 3). The creation of a more uniform pattern was viewed as a way of increasing the aesthetical appeal of the treated timber.

Subsequent work showed:

1. The treatment trials undertaken demonstrated that similar uptakes of preservative solution were achieved at 90 minutes and 180 minutes under pressure. This seemingly indicated that the maximum absorption is reached relatively early in the cycle and the additional time may be unnecessary.

2. There was a very similar uptake of preservative solution between the two incising patterns, however, the pattern of distribution is different. The effectiveness of patterns could only be determined through long-term field trials.

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3. Spruce that is fast grown may have a different uptake of preservative solution as it can penetrate the timber via the spring wood of the growth rings.
4. Incising was shown to increase the depth of penetration significantly. Further work was necessary to ascertain options for 15, 30 and 60 year service lives.
5. Incising has an application in the specified quality fencing market and other high quality applications.
6. Issues of strength loss were not studied sufficiently to determine actual percentage losses.

Figure 3: Picture of new incising pattern (top) old pattern (middle) and no incising (bottom) before treatment.

In addition to the scientific work carried out, a state of the art review was also undertaken (Suttie 2002), outlining all methods for improving the uptake of preservatives currently in use worldwide.

The promotion of results achieved within this second study resulted in a positive response from the UK wood-working industry, preservative manufacturers and timber retailers. One of the main attractions was the increased consistency in levels of treatment. At the time of the delivery of this second study, sawmillers recognised the potential being offered from incised timbers, though uptake has not occurred, presumably as a result of additional equipment and processing costs. Despite the belief that the appearance of incised wood offered potential in high quality products, industry was reluctant to view this similarly, suggesting further evaluations of customer perception were required.

The need to increase the preservative uptake of UK species is essential in maintaining the proposed business opportunities in Hazard Class 4 situations. UK grown Sitka spruce is becoming available in large

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quantities and sizes suitable for the construction industry. In many ways spruce can be an excellent construction timber. It also has a cell structure that gives it a relatively low permeability to water, but like other constructional softwoods, it is susceptible to fungal and insect attack when not treated. Impregnation with wood preservatives by normal pressure methods achieves relatively poor penetration and therefore only modest enhanced protection. Increasing treatment pressures to improve penetration can lead to the collapse of the timber cell structure. Douglas fir and Larch have similar preservative treatment difficulties to Spruce. By incising the surface of these timbers prior to preservative treatment, it is hoped to demonstrate a greater consistency of treatment penetration, loading of the active ingredients and possibly improved conferred durability.

In order to better demonstrate the suitability of UK grown softwoods for in-ground contact uses, BRE erected several trial fences as part of a long-term product demonstration (Figure 4). These have been in service for 5 years so far, and show no indication of decay to date.

Figure 4: Incised timber fencing erected at BRE, Garston.

Work covered within this report outlines developments from the initial development of the new incising pattern, with the manufacture of a pilot scale incising machine, and the subsequent preservation tests undertaken in association with Arch Timber Protection, Castelford.

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Development of pilot scale incising apparatus

In order to further the development and acceptance of the new incising pattern, it was necessary to set up and test pilot scale production equipment. This was undertaken at BRE Garston. The aim was to convert a grading machine in such a way as to mimic a commercial incising apparatus. This is shown in Figure 5.

Figure 5: Apparatus used for pilot scale incising.

In order for the timber to pass through the machine, the drive mechanism present for grading purposes was maintained, these rollers being used to drive the timber. The two blocks of incision blades were freely of motorisation, so flow of timber depended solely on the drive rollers. Both of the blade blocks were spring mounted to allow for any variation in thickness/straightness of the timber being incised. The maximum width setting for the equipment was 75mm. The blades were orientated in such a fashion (Figure 6) as to allow incision on two opposing faces per run of timber through the machine. Therefore to gain incision on all 4 faces would require two passes of the timber, with manual turning of the timber through 90^{o}.

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Figure 6: Incision of opposing sides as timber is driven through the machine.

Experience gained during the incising of the timber samples suggests that the following improvements could be made to future prototypes, should they be needed:

- Incise all 4 sides during a single pass of the timber beam, if necessary staggering the position of the blade blocks (e.g. horizontal blocks at one point, followed by vertical blocks further along the pass)
- The ability to incise samples greater than 75mm
- Introducing the driving motors into the incising blocks

These modifications may be undertaken on this prototype machine if necessary (other than increasing maximum sample size).

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Uptake of preservative treatment

In order to determine the effectiveness of the incising process, it was necessary to preservative treat the timber. To this end, a range of material cut to 1.95m lengths and of cross section 75 x 75mm, representing incised and non-incised material, was sent to Arch Timber Protection, Castleford. Here treatment using Tanalith E 3494 was carried out under standard commercial practice using two differing schedules:

- Schedule 1: Initial vacuum period of 60 minutes at 600mm Hg; pressure period of 180 minutes at 12.8 $kgcm^{-2}$; final vacuum period of 15 minutes at 600mm Hg
- Schedule 2: Initial vacuum period of 15 minutes at 600mm Hg; pressure period of 60 minutes at 12.8 $kgcm^{-2}$; final vacuum period of 15 minutes at 600mm Hg

In addition, two different concentrations were used during the trials: C1 = 2.74%; C2 = 4.57% (both w/v).

The results of preservative uptake are listed in Table 1.

Schedule	Concentration (% w/v)	Incised	Average Weight uptake (g)	Standard Deviation
1	2.74	No	1768.3	634.3
1	2.74	Yes	2246.1	519.4
2	2.74	No	1306.0	725.1
2	2.74	Yes	2015.8	814.5
2	4.57	No	1204.3	362.0
2	4.57	Yes	2018.7	435.3

Table 1: Overview of preservation uptake trials undertaken at Arch Timber Protection Ltd.

It would appear from the results in Table 1 that there was little benefit gained from using a higher concentration of Tanalith E solution, given the similarity in uptake, especially where the samples had been incised prior to treatment.

Once treated the samples were returned to BRE for assessment of preservative penetration.

Figures 7 to 9 show the levels of preservative uptake for the following trials; schedule 1 using C1, schedule 2 using C1 and schedule 2 using C2 respectively. In each figure, the top two rows represent samples of incised timbers, whilst the bottom two rows are of non-incised timbers. For each sample, the timber has been cut 250mm from their ends, where the Tanalith E solutions have been stained with chrome azurol S dye solution. The use of this dye creates a more visible darkening of treated regions.

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Figure 7: Visual assessment of samples treated using schedule 1 with 2.74% Tanalith E

Figure 8: Visual assessment of samples treated using schedule 2 with 2.74% Tanalith E

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Figure 9: Visual assessment of samples treated using schedule 2 with 4.57% Tanalith E.

In each of the three visual assessments, it can be seen that there is generally higher levels of staining in the upper two rows. These rows represent the incised samples from that particular batch preservation run. Table 2 gives an overview of penetration assessments.

Schedule	Concentration (% w/v)	Incised	Minimum penetration depth (mm)	Maximum penetration depth (mm)	Typical penetration depth (mm)
1	2.74	No	2.0	10.5	4.1
1	2.74	Yes	3.2	13.8	6.0
2	2.74	No	1.3	9.1	2.6
2	2.74	Yes	2.7	13.8	6.7
2	4.57	No	1.6	8.0	2.9
2	4.57	Yes	3.7	11.6	6.7

Table 2: Depth penetration analysis for preservative treated samples

In order to meet the requirements defined within BS 8417, the following criteria must be reached:

- 15 year service life – P4 penetration (minimum 6mm lateral penetration); preservative retention 15kg/m3 (CCA) or 1.5 times critical value

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- 30 year service life – P6 penetration (minimum 12mm lateral penetration); preservative retention 15kg/m3 (CCA) or 1.5 times critical value
- 60 year service life – no recommendations

The results show that, whilst there is an appreciable improvement in the minimum penetrative depth of preservative treatment following incising, the requirements stipulated within BS 8417 are not met for P4 treatment suitable for 15 years service life. The average penetrative depth for incised samples treated using schedule 2 appear to provide values suitable for P4, though the individual minima is considerably lower than stipulated. However, the levels of preservative retention are not sufficiently high in any of the cases assessed to meet the 15 kg/m^3 requirement within BS 8417. The typical levels of retention were found to be around 5.0 and 5.6 kg/m^3 respectively for treatments using the lower concentration solution, and 8.4 kg/m^3 with the higher concentration.

This study would appear to show that whilst considerable improvements in preservative uptake could be achieved, they were not sufficient to allow for Sitka spruce to be used in Hazard Class 4 scenarios where a 15-year service life is required.

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Cost implications of incising

The wood preservation industry and the range of products dependent on the use of such material is one of the most restricted markets in terms of price fluctuation. Significant changes in the unit cost of a product can decimate its market share. The previous study by BRE (McMinn 2004) included an interview of several timber companies. This showed that there was a concern over the add-on costs, and whether traditional products (such as fence-posts) could absorb these costs, whilst remaining competitive. A press release (Suttie 2004) referred to the estimated costs of incising, expressed as an add-on cost, excluding the initial cost of equipment. This was based on an earlier BRE report (Suttie 2002), looking at incising for creating a specific commodity of highway fencing posts, whereby the timber treater should be able to recover the estimated £45,000 investment in incising equipment within 3 to 4 months of production. This estimate is based on savings of £15/m^3 in timber costs alone (£95/m^3 for spruce "green" posts compared with £110/m^3 for Douglas fir) with a through put of 750m^3 per month. The incising process is estimated to add £5 per m^3 to costs in additional electricity consumed and wood preservative costs. The cost of machinery investment is based on commercial scale equipment, similar to that shown in Figure 10, an example from South Africa (Suttie 2002).

Figure 10: Commercial incising equipment in use in South Africa.

One of the targeted market areas for incised timber is linked to road safety, through improved fencing. The Highways Agency are responsible for 10,000 km of motorways and trunk roads in England. For their post and rail fences a total volume of 182,700 m^3 treated timber fence posts and 141,750 m^3 of treated timber fence rails are estimated to be in service. Assuming the 40 year service life is achieved an estimated 3% of the volume will need replacing each year equivalent to 10,000m^3. New roads and improvements to highway safety will increase this volume. At present, there are no UK companies producing incised timber for this

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market, and this represents a ready made market for incised UK timbers such as Sitka spruce, larch and Douglas fir. Table 3 provides an overview (Suttie 2002) of typical costs for commercial production, though this does not take into account the recent increases in unit electricity costs.

Species	Size (cross section)	Treatment	Estimated service life	Estimated costs £/m^3
Douglas fir	145 x 75 mm	CCA	40 years (BS5589)	£140-£150
Pine	145 x 75 mm	CCA	40 years (BS5589)	£170
Spruce (unincised)	50 x 50 mm	CCA	11 years (UK field trial)	£125
Spruce (incised)	50 x 50 mm	CCA	>49 years (UK field trial)	£135-£145

Table 3: Comparison of costs of timbers suitable for use by the Highways Agency (Suttie 2002).

The estimated service life for incised Sitka spruce listed in Table 3 is based on previous trials into incising at BRE, with all data related to CCA. It will be necessary to determine the improvements in service life of material treated in this study (treated with Tanalith E 3494), given post-treatment measurements seem to not comply with requirements for P4 treatment according to BS 8417. That said, the incised Sitka produced in this study will have a service life greater than non-incised material treated with the same preservative.

Whilst there appears to be a market ready to use incised timbers, it is still necessary to engage commercial activity. To do this, there must be a financial certainty of success. At present the cost of electrical supply is making this less likely to occur, though these costs fluctuate, as has been demonstrated over the past 2 years.

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Presentation on Incising

The following represents a presentation given to the highways Agency in May 2006 outlining the ongoing work into incising. The presentation was well received, with the consensus at the meeting being that incising could offer a way forward for use in highway situations, provided strength losses could be minimised.

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Background

- UK grown softwoods
  - Sitka spruce
  - Douglas fir
  - Larch
- Increasing available stock
- Relatively low commercial value
- Adequate strength characteristics
- Relatively low water permeability
- Low to Moderate natural durability

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Durability

- Majority UK softwood supply too low in natural durability for Use Class 4 applications (ground contact).
- Need to enhance performance

- Solution – Preservation
- Problem – Permeability

- Need to increase the depth of envelope treatment
- Solution – Incising

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Mechanical Incising

- Puncture surface of wood
- Increase solution penetration
  - Greater depth
- Deeper envelope treatment
- Original work chisel shape cutters
- Current work triangular blades

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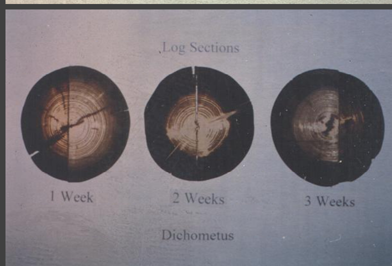
Other methods of incising

- Biological incising
  - Dichometus
  - Trichoderma
  - Phanerochaete
- Slow process
- Logistics
- Work carried out mainly in Austria
  - Also Dundee University



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Previous work

- Work undertaken in the 1970's
- Samples exposed in 1972.
- Significant increase in service life
  - In excess of 55 years compared to non-incised, untreated posts (11 years).
  - Original work with CCA (full cell process)

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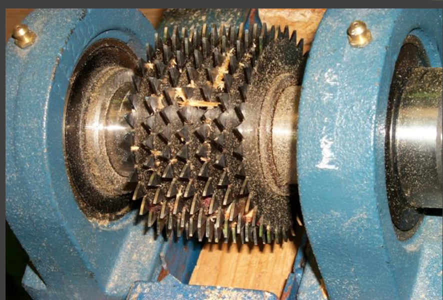
Current work

- Using new pattern
- Compare results of Cu azole treatment with old pattern and non-incised.
  - Sitka spruce
  - Douglas fir
  - Larch



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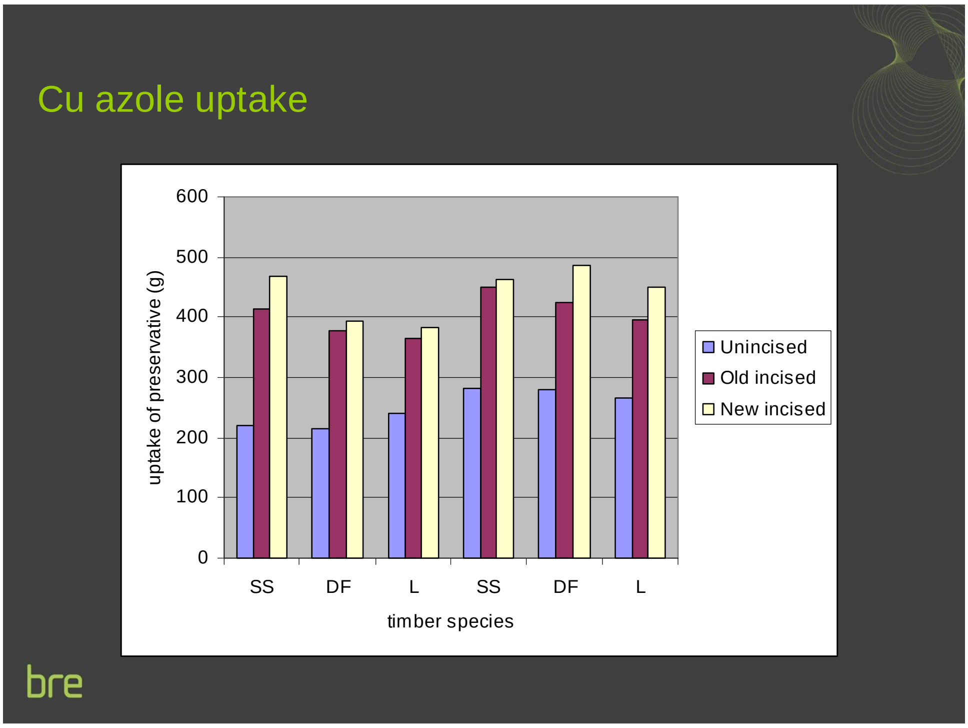

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Products in service

- Fencing trials at BRE Garston and BRE East Kilbride
- Proof of principle
- Field trials set up in 2004
  - Compare to 1972 results

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SWOT analysis - Strengths

- Ability to use locally grown timber
- Consistent supply of timber
- Improved penetration and retention of preservative
- Improved durability of commodity (longer life)
- Reduced stresses in commodity – less checking

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SWOT analysis - weaknesses

- Aesthetics
- Perceived process costs
- Capital outlay on equipment
- Outside existing specifications
- Lack of understanding of performance properties of incised timber

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SWOT analysis - opportunities

- New products
- Demonstrate end results requirements of BS8417 for penetration and retention
- Reduce timber waste due to premature failure in service
- Readily identified as being incised and treated
- Reduced processing times

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SWOT analysis - threats

- Cheaper imported timber
- Other materials
- Added cost in highly price sensitive market
- Largely untested market

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Market perceptions

- Seen as offering benefit to local timber supply chain
- Increased service life
- Consistent treatability
- Potential for quality assurance

- Estimate limited add-on cost (approx £5 per m^3)

- Issues with surface finish
- Increased use of preservatives

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Conclusion and recommendations

Incising remains an excellent way of increasing the performance and hence the service life of UK grown timbers in Hazard Class 4 situations.

Whilst there are no commercial activities ongoing with incising in the UK at present, there remains interest in its use, especially from end-users such as the Highways Agency. The fluctuating price of electricity can seriously affect business opportunities for incising.

Results from the pilot scale operation developed at BRE suggest a considerable improvement in preservative uptake and lateral penetrative depth, but not to the level stipulated for P4 treatment within BS 8417. However the increase in preservative uptake will results in a significant improvement in service life.

Further work will be required to compare results from current preservative treatments and those previously published for CCA. Likewise the increase in service life of incised Sitka spruce compared to non-incised material would also need to be resolved.

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