Reducing waste in timber procurement is critical to replacement of original wooden shingle roofs on heritage buildings at Norfolk Island

John Cokley

School of Journalism and Communication, Blair Drive, University of Queensland, Queensland 4072, Australia
Email: j.cokley@uq.edu.au

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Summary

Traditional timber cutting, recovery and installation processes used by loggers and builders on Norfolk Island are a major impediment to the continued and sustainable restoration and maintenance of historic buildings at the southern tip of the island. Sustainable restoration and maintenance is likely to be a contributing factor in the expected decision by UNESCO about whether the island is included on the World Heritage List.

Keywords: shingles; roofs; durability; historic sites; heritage tourism; Araucaria heterophylla; Norfolk Island

Background

Norfolk Island, a self-governing Australian territory, is in the Pacific Ocean east of the Australian mainland and has an area of 34.6 km². The Kingston and Arthurs Vale Historic Area (KAVHA) at the southern tip of the island is of exceptional historical and social value and is included on the Australian National Heritage List (Australian Department of Environment, Water, Heritage and the Arts 2008). It also formed part of the 2008 nomination by the Australian Government for World Heritage listing by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) for decision in 2009. The KAVHA site has four distinct settlement periods: Pre-European, two European and a mixed British/European/Polynesian settlement. The precinct contains a fine collection of colonial Georgian buildings that functioned as a convict settlement. The buildings have been stabilised by a program of restoration and conservation which is detailed in the KAVHA Management Plan (2008). This article addresses the most significant maintenance program in the precinct to date, that of restoring and repairing the original Norfolk Island pine shingles on the roofs of the historic buildings. This program commenced in 1985 (P. Anderson, Norfolk Island, 2008, pers. comm.) and effectively concluded 23 years later on 30 June 2008 (Vicky Jack, Norfolk Island, 2008, pers. comm.).

Method

This study included a literature review, observation and case studies (observation and interviews). The use of such a combination of methods, identified by Berg (2001) as ‘triangulation’, is accepted, indeed recommended, as a way to describe ‘multiple data-collection technologies designed to measure a single concept or construct (data triangulation)’ that allows ‘mutual confirmation of measures and validation of findings’ and ‘a means of refining, broadening, and strengthening conceptual linkages’:

The important feature of triangulation is not the simple combination of different kinds of data but the attempt to relate them so as to counteract the threats to validity identified in each.

In particular, use of case studies is supported by Berg (2001) who notes that ‘case study methods involve systematically gathering enough information about a particular person, social setting, event or group to permit the researcher to effectively understand how it operates or functions’ and that ‘the scientific benefit of the case study method lies in its ability to open the way for discoveries’. They may focus on ‘an individual, a group or an entire community and may utilise a number of data technologies such as life histories, documents, oral histories, in-depth interviews, and participant observation’ (Berg 2001).

The site

The vernacular buildings at KAVHA were built by hand using materials collected and worked from the vicinity (KAVHA Management Plan 2008). This document indicates that not all these materials are available today. For example, endemic Norfolk Island pine shingles were the original roofing material and hence the choice for authenticity. However, these shingles deteriorate quickly and require regular costly replacement that uses scarce resources. As a compromise Casuarina tortulosa shingles from New South Wales on the Australian mainland have been used in recent years to re-roof small prominent buildings. This shingle was the original material only on the Surgeons Quarters building, a building constructed during the Second Penal Colony. The original casuarina shingles were imported from Sydney, where casuarina and ironbark shingles were commonly used. Presumably the durability of these hardwood shingles had been well established for the Sydney region.

The KAVHA plan states that the casuarina shingles are available in limited supply and are expensive since they are imported. The expense increases because they are pre-cut in Australia (P. Anderson, ibid.) rather than being split on the island. The plan suggests that the shingles be monitored and alternative species tested if the supply becomes inadequate. The plan also suggests...
that present supplies of Norfolk Island pine are inadequate for large-scale use for shingles. However, the management committee also concluded that should supplies of the pine become available and or treatment methods be developed that extend the durability of the pine shingles then these should be used as the preferred roofing material. Given the high cultural heritage values of KAVHA it is essential that future conservation be carried out in accordance with best conservation practice and methods. Generally, all authentic fabric must be conserved. As an aside, shingle trimming and laying adds to the interpretation of the area and demonstrations are given at occasional events and for tourists. Interpretation (writing and installation of signs) has largely replaced re-roofing in the KAVHA budget from July 2008 (Jack, ibid.).

Norfolk Island pine wood

Norfolk Island pine (*Araucaria heterophylla*) is a conifer but not a true pine (Earl 1998). As its vernacular name suggests it is endemic to Norfolk Island and the name is mostly shortened by islanders to ‘Norfolk pine’. Norfolk Island pine trees grow to a height of 50–65 m with straight vertical trunks and hard, extremely durable limbs. The 18th century English explorer Captain James Cook encountered these trees and he and others (Moorehead 1966; Lennon 2005) considered that they would provide ship masts, after which the trees were planted on many locations in the South Pacific including Lord Howe Island, New Zealand and Hawaii (Lennon 2005). Unfortunately the wood proved too weak for this maritime purpose. In the late 1950s a trial shipment of Norfolk Island pine logs was sent to Sydney for plywood manufacturers but the industry was deemed not sustainable by the Norfolk Island Advisory Council. The wood is light coloured and soft, with a knotty pine character and strength characteristics similar to those of Northern Hemisphere Douglas-fir (INTAD 2001). It is excellent for turning and is used extensively by Hawaiian craftspeople (HFIA 2000). Another species of *Araucaria*, hoop pine, is grown extensively in plantations in Australia, while para pine once occurred in extensive natural forests in Brazil. These woods, of low natural durability, are used principally for timber framing, interior woodwork, furniture and veneer (INTAD 2001) and not for exterior applications.

The Norfolk Island government passed the *Trees Act 1997* to preserve and manage protected trees such as Norfolk Island pine. There has been significant planting of pines and other native trees on the island for the past ten years with the view of the island becoming self-sustaining for timber (Lennon 2005). Four hectares of pine were expected to be planted annually after 1985 (Benson 1985).

Wooden shingle and shake roofs

Wood shakes and shingles are a traditional roof covering. The difference between a shingle and shake is that a shake is made by splitting a log longitudinally and it is normally thicker than a shingle (Niemiec and Brown 1993). Today this type of roof is constructed frequently in the US and Canada and remains servicable for lengthy periods. Shingles (A. Evans, Norfolk Island, 2008, *pers. comm.*) are produced by cross-cutting logs, shaping them into smaller sections and then splitting off the final shingle.

As a roofing material, shingles are exposed to weathering from sun, wind, debris and precipitation, resulting in rough surfaces and loss of dimensional stability (Salaita *et al.* 2008). Durable shingle roofs have been made by using durable timbers that are able to repel water and resist decay. In the US, western red cedar has provided such a timber as it is naturally water repellent, and gums in the heartwood inhibit the growth of lichens, mould and fungi. The heartwood of old-growth western cedar is rated as extremely durable, although the generally small amount of sapwood of this species is not. The heartwood and sapwood in a species can be very different (Taylor *et al.* 2002). There is general consensus (Cokley 1995; Nolan 2004; Meynink 2006) that maturity, speed of growth (often rapid in regrowth and plantations) and source location (e.g. ridge-grown or valley-grown) are related to durability. Therefore the age and origin of Norfolk Island pine trees considered for shingles may be an important factor in their selection.

Western red cedar timber is a declining resource and wood from other species is being used as an alternative (De Groot 1994). The wood may be durable heartwood and non-durable sapwood, or entirely non-durable wood. The durability of shingles and shakes can be improved by wood preservation, and even durable woods are treated to increase longevity (Feist and Hon 1984). A wide range of treatments are used to preserve timber generally and are categorised into pressure treated and surface applied, either oil- or water-borne (Dickey 2003). Wood from softwoods such as western hemlock, pacific fir, grand fir, western white pine and red alder has been used successfully for shake production in Canada and the US (De Groot 1994). These shakes were pressure-treated with chromated copper arsenate (CCA). Treated shakes from southern yellow pine have a guaranteed lifespan of 50 years (Horton *et al.* 1994).

In the past decade, a number of successful preservation treatments have been banned for certain uses because of reported adverse effects on human health and environmental parameters (Dickey 2003; Evans 2003). The banned treatments include creosote, CCA and pentachlorophenol (PCP). As an example of the effects of these chemicals, Kalnis and Detroy (1984) showed that the leaching of chemicals from treated softwood beehives had a detrimental effect on bee colonies and honey production. The treatments used to treat shakes in the past decade can no longer be used. Current research on wood preservatives has focused on the development of environmentally benign treatments (Termiz *et al.* 2008). Evans (2003) reviewed recent advances in wood protection. A large number of biocides originally used for agriculture are now being introduced as effective preservatives. Another area of advance is through the modification of wood by heat treatment which improves resistance to bio-corrosion and reduces hygroscopicity (Gosselink *et al.* 2004; Gunduz *et al.* 2007). The resistance of carbonised wood to environmental decay may be similar to or even better than that of creosote-impregnated wood (Gunduz *et al.* 2007). The temperatures at which the wood is treated range from 180 to 200°C. This type of treatment could be tested on Norfolk Island.

Wood finishes can provide protection against degradation from ultraviolet light and absorption of water into the timber (Loferski 1999). These materials usually contain a fungicide, a drying oil, a solvent and a small amount of water-repellent material such
as wax or glycol. Crude tall oil, a by-product of the pulping of resinous softwoods, has been used as an effective wood preservative (Termiz et al. 2008). Shingles traditionally have been treated with copper or zinc naphthenate (Niemiec and Brown 1993; MacLellan and Wolfson 2004). These are both low-toxicity compounds (Dickey 2003) and have been reported as useful for bee colonies (M. Kennedy, Queensland Department of Primary Industries and Fisheries, 2006, pers. comm.). The use of copper compounds may not be acceptable for historic buildings as they may leave a green residue (Lokerski 1999). Zinc naphthenate could prove an acceptable preservative for Norfolk Island as De Groot and Stroukoff (1988) reported that pine boxes in humid jungle conditions resisted decay following zinc naphthenate treatment as well as or better than those treated with PCP.

Norfolk Island pine wood is susceptible to borer and most pine used on the island is treated at the tanalith plant on the island (Lennon 2005). Talith (Tanalised E) is a copper-based wood preservative originally developed in Europe in the 1980s. The preservative provides protection against most types of decay and termites. A synthetic azole-type co-bicide provides protection against copper-tolerant organisms such as brown rot fungi. De Groot and Nesenson (1995), in a review of preservatives for shakes, noted that copper azole was an effective treatment.

Relevance to the World Heritage Convention

Discussion of the KAVHA restoration work in relation to the UNESCO World Heritage Convention (1972) is especially apt since the first paragraph of the convention’s preamble notes that ‘the cultural heritage and the natural heritage are increasingly threatened with destruction not only by the traditional causes of decay, but also by changing social and economic conditions which aggravate the situation with even more formidable phenomena of damage or destruction’. The subject of this article — shingle roofing of Norfolk Island pine at the KAVHA precinct — has proved to be vulnerable to the causes of decay mentioned in the preamble: physical (rot and insect attack) and political (changing social and economic conditions).

Notwithstanding the decision of the World Heritage Committee in 2009, the KAVHA precinct itself seems to be covered by the list’s definition in Article 1 (UNESCO 1972) of cultural heritage: ‘groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science’. The aims of the Norfolk Island Administration seem also to be well aligned with Article 5, paragraph 1 (KAVHA 2008) that recommends the adoption of ‘a general policy which aims to give the cultural and natural heritage a function in the life of the community and to integrate the protection of that heritage into comprehensive planning programs’. This article is well aligned with UNESCO (1972) Article 5(c), which recommends the development of ‘scientific and technical studies and research … to work out such operating methods as will make the state capable of counteracting the dangers that threaten its cultural or natural heritage’.

The World Heritage List includes 679 cultural sites, 174 natural sites and 25 mixed-site properties in 145 states. Cultural sites outnumber combined natural and mixed sites by more than three to one. In Australia there are 17 sites, only two of which...
The island woodworker, who agreed to be interviewed but did not agree to be named in this article, demonstrated his methods of turning Norfolk Island pine into tables, bowls, platters, inlaid clocks and thermometers, and other items for sale in island souvenir shops. He showed the author slabs of pine that had been subject to insect attack and rot, and others which had been treated with various chemicals, such as the insecticides Metalex and Borid (boric acid powder). At the island mill, I viewed milling equipment that dated to World War II and I discussed the logging and milling of the island pine with the owner, Mr Howard Christian. Locals on the island referred to Mr Christian as the man who knew most about logging and building with Norfolk Island pine, and indeed his mill compound — largely open-air with several portable and ‘forest mills’ and planers scattered about — showed evidence of long-term use. During the progressive dinner, an evening event during which tourists are driven for meal courses in a small coach between three houses owned by long-time islander families, the author viewed houses in which Norfolk Island pine furniture and interior fittings were displayed prominently and discussed extensively. Mr Christian was mentioned often during the night as the person responsible for felling, milling and carting the timbers of which the islanders were evidently very proud. His role in the community appeared to be one of overseer of the endemic timber resource, and the person whom young families approached to have timber cut from their family blocks and milled to order into timber for their homes. The pine, as an interior and furniture timber, appeared to be a key tourism driver on the island, and an object of substantial pride among long-term residents. At the Tanalith plant, I met the manager, Mr Bevon Nicolai. He said that the plant was a second-hand cold vacuum pressure model (1500 kPa) installed in 1948, using the CCA product Tanalith E manufactured by Koppers. This was sufficient to deter the endemic pine beetle, the pine hole borer, the wood roach and various species of fungi.

**Case studies: interviews**

Subjects chosen for interviews were builders, politicians, a museum director and a history-tourism worker.

Restoration project manager Mr G.E. ‘Puss’ Anderson, his son Kane, and Mick Williams were the team of builders who concluded the restoration project in June 2008. Others had worked on the project from time to time since restoration commenced in 1985. The principal task had been removal of asbestos tiles and decayed pine shingles and progressive replacement with alternative materials. The Administration had made a long-standing budget allocation of $50,000 a year towards the work but it was recognised that the actual costs of re-roofing would be more than that (Jack, ibid.). Removal of in-situ asbestos tiles required shipping the hazardous material from the island to a suitable deep land-fill site in Australia. The cost of shingles alone for an average-sized building in KAVHA was up to $AUD200,000, compounded by the cost of other building materials and labour. The most recent estimate to completely re-shingle one building was $AUD200,000 (Jack, ibid.). The allocated budget of $50,000 will now be redirected to improving signs and other historical interpretation within the site, home to the island’s Legislative Assembly, its administrative offices, Government House and the group of intact buildings and ruins dating from Norfolk Island’s 19th century convict days.

The shingling program, initiated in 1985 by heritage architect Robert Varnam, later of the University of Sydney (P. Anderson, ibid.), initially specified the endemic Norfolk Island pine, but the service life of untreated natural timber was only five years. (Records from the early settlements suggested those settlers also both preferred Norfolk Island pine timber and experienced the resultant decay and replacement issues.) The builders tried applying a Wattyl coating called ‘Combat’ but service life extended only to 9–10 years (P. Anderson, ibid.). Treatment of pine shingles at the island’s Tanalith plant — commonly used to add copper chromium arsenate (CCA) preservative to building timbers cut on the island — was rejected for the KAVHA site because the chemicals turn the timber green and there was a concern that run-off from the roofs would contaminate the ground around the site (see Cookson 2008). In 1990, installation began of casuarina shingles supplied by Shingles Australia of Mullumbimby in northern New South Wales. These shingles had an expected service life of 80 years. However, the builders found the casuarina very hard to work (P. Anderson, ibid.):

> It’s a very hard timber … We had been nailing the Norfolk pine on by hand but we needed nail guns to put up the casuarina. There’s a natural grain through it, too, so it’s tough and doesn’t split easily. They have to use a hydraulic splitter.

The imported shingles cost about $AUD200 per square metre, machine cut and landed on Norfolk Island (32 shingles in a square metre). Installation and equipment costs reached another $AUD200 per square metre (P. Anderson, ibid.).

The island’s *Tree Preservation Act* includes strict rules for logging local Norfolk Island pine. Only dead or dying trees may be taken and the shingle team has very specific requirements: excellent quality, clean butt logs with at least 20–30 feet (6 m) from ground to the first limb. Nevertheless, ‘Norfolk pine was the only suitable timber to make roofing shingles in the early days’ (Evans, ibid.) and so it was initially the preferred material. After recovery (felling and dragging out), each butt log is cut into 18-inch (about 450-mm) lengths called ‘juncts’ (Evans, ibid.). These juncts are stood end-on and a pattern board, 4½ inches (about 110 mm) wide, is laid across the middle of the junct to mark out what craftsmen call a ‘billet’. From the billet (using a froe — an iron blade on a wooden handle, sharpened on one side and blunt on the other — with a wooden mallet) are cut shingles ½ inch (about 10 mm) thick and 18 inches long. Since only a third of each shingle is exposed on the roof (6 inches by 4½ inches wide) about 30,000 shingles are required for the roof of an average three-bedroom house. The pitch of the roof should be more than 37° to reduce water damage and rot and thus maximise service life (Evans, ibid.). The limbs of the pine are tough and durable but they make timber adjacent to their knots unsuitable for shingling, causing substantial wastage of otherwise millable timber (P. Anderson, ibid.).

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1 Most men on Norfolk Island are more commonly known by nicknames.  
Hardiflex, a cellulose fibre-cement product, has also been used on some buildings at the site but according to the builders this did not supply an authentic timber shingle appearance.

‘Timber is extensively used at the landing place,’ said Puss Anderson. ‘We want to use traditional materials as far as possible.’ His fellow builder Kane Anderson said: ‘It’s part of our identity. Tourists and residents always ask: “What are the roof shingles made of?”’ and comment on how good they look. These are the most-asked questions.’ Locals use significant pines on hilltops and outcrops as navigation points for fishing, and as Puss Anderson said: ‘it’s the first thing you see when you approach the island’.

The view that casuarina or Hardiflex disrupts the interpretive value of the KAVHA site is challenged by the Administration’s Environment Minister Mrs Vicky Jack: ‘I don’t think the majority of tourists who visit the site even notice or consider the particular aspect of the type of shingles used on the various roofs within the KAVHA site. Their consideration is given to the overall view, the panorama of the site. As to how the local community thinks about the type of shingle used … in my 17 years living on Norfolk, the type of shingles on roofs within KAVHA has never made it into any conversation outside my work environment.’

Museum director Brian Hubber agreed with this view. ‘When visitors come to Norfolk Island they know that the island has a strong convict heritage and they have a general idea about the history of the place. But most people wouldn’t even know what kind of timber is used on the roofs.’ However, he acknowledged that ‘purists’ would argue that using anything other than authentic materials would be the thin end of the wedge, and that this ‘chips away at the authenticity of the buildings’. The best solution in his opinion would be a roofing material that would last, would be financially sustainable and would use materials that are available on the island.

**Discussion**

The literature suggests that one of the most significant aspects of the convict site at KAVHA is that the buildings were made by hand using materials collected and worked from the vicinity. The most suitable and readily available roofing material was shingles of Norfolk Island pine (Evans, ibid.), a fact that suggests this material should be chosen for authenticity during contemporary restoration (KAVHA 2008). Only one building, the surgeons quarters (Second Penal Colony), was originally fitted with imported casuarina shingles (P. Anderson, ibid.). The case for the use of the pine is strengthened by the island economy’s reliance on tourism, much of which is driven by visits to the KAVHA historic precinct (Evans, ibid.; K. Anderson, ibid.), the souvenir trade and the progressive dinners. The Administration has recognised this by reallocating annual funding of $AUD50 000 from re-roofing work to interpretation work around KAVHA (Jack, ibid.).

There are however two arguments against the choice of Norfolk Island pine for re-roofing. The first is that supplies of the wood are very tightly regulated by contemporary legislation, and secondly the timber is very vulnerable to attack by insects and rot without the use of CCA-based treatments, which are rejected on environmental grounds. The second choice of roofing material, casuarina, is expensive, hard to work and reliant on suppliers in Australia (P. Anderson, ibid.) but its service life extends to almost a century.

The supply of island pine is not so tightly regulated as to prevent islanders from securing wood for wood turning for the tourist trade and for traditional house building. Nor is on-island regulation a factor in KAVHA’s ability to secure supplies of Norfolk Island pine for roofing from areas planted elsewhere, such as Lord Howe Island, Hawaii and New Zealand. The only foreseeable extra expenses are the costs of transport by sea and possibly quarantine facilities, but these are mitigated by the identified significant present costs in milling, importing and installing the very hard casuarina wood.

Convenient and inexpensive CCA treatment facilities already exist on Norfolk Island at the Tanalith plant near the central town of Burnt Pine. This is the standard treatment for the wood logged and milled on the island for house-building by traditional island families. Other treatments are identified in this article, such as the low-toxicity and environmentally benign compounds copper or zinc naphthenate, and carbonisation by heat treatment.

It is likely that Norfolk Island pine could provide durable shingles if the timber is treated appropriately. It would be best if this treatment could be undertaken on site, thereby reducing costs. In addition, other endemic species on Norfolk Island may provide a sustainable supply of wood for shingles. Alternatively, as Norfolk Island pine growing on Lord Howe Island is genetically the same as that on Norfolk Island, timber from that island could be considered as an additional authentic supply.

**Conclusions and recommendations**

The research conducted for this article strongly suggests that the issue of a sustainable resource to supply authentic timber shingles for the KAVHA historic precinct is one of social and political will rather than availability of materials or cost. Documents reviewed and interviews conducted suggest that the available resource of Norfolk Island pine on the island is sufficient to supply KAVHA needs into the future even with the expensive and apparently wasteful crafting methods of the traditional roofing process — and even with the existing exploitation for tourist souvenirs and traditional islander housing and the legislated need to conserve existing forests. A less wasteful method of logging, milling and crafting the pine into shingles would improve the effective size of the timber resource. Beyond the island lie further resources of Norfolk Island pine which might be acquired, milled, treated and installed at less expense than the casuarina currently imported from Australia. The research also strongly suggests that treatments are available for the pine that extend the service life of the timber without risking permanent damage to the environment or the authenticity of the KAVHA precinct.

The fundamental issue identified in this study is that the island economy depends on tourism driven by history visits, in turn encouraged by inclusion of the island on lists such as the UNESCO World Heritage list. The likelihood of the KAVHA precinct being added to the UNESCO World Heritage list in 2009 deliberations...
would be much enhanced by the use of authentic Norfolk Island pine roofing material at the KAVHA site.

Further research

I recommend that further research and testing be conducted to reduce the waste incurred in the logging and milling of Norfolk Island pine for shingling, and into the sustainable and environmentally benign treatment of the timber prior to use on the historic buildings.

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