Redwood Preservation at Scotty's Castle
Death Valley National Park

School of Engineering, University of Vermont
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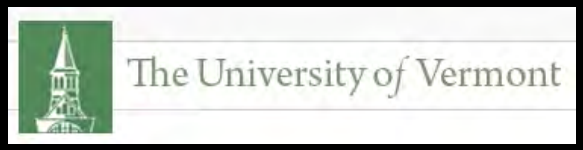

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Project partners include:
Curation, Death Valley National Park
Atlas Material Testing Solutions
Conservation Associates
Vanishing Treasures Program (NPS)

The University of Vermont

Redwood Preservation at Scotty's Castle, Death Valley National Park

Constructed in the 1920s, Scotty's Castle is an eclectic revival estate constructed for Chicago millionaire Albert Johnson. Buildings are constructed of cast-in-place concrete and wood frame with hollow clay tile infill. Millwork incorporates hundreds of thousands of board feet of old-growth redwood.

Redwood Preservation at Scotty's Castle, Death Valley National Park

DAMAGE TYPOLOGY: FINISH

CRAZING

Coatings become brittle with age, resulting in mechanical failure at the surface. Under magnification, crazing appears as a network of small cracks, often relatively regularly spaced. Crazing can result in a hazy or cloudy overall appearance. Film coherence can continue to degrade until cracks completely penetrate the coating, resulting in a surface covered in discrete "flakes".

Fig 1 shows a crazed surface at an early stage, with pronounced clouding in several regions; in Fig 2, cracks penetrate the entire thickness of the film and the coating has begun to detach from the substrate. Fig 3 shows a relatively unaffected surface under magnification; "ridges" are due to wire-brushing of the surface during the finishing process. In Fig 4, the film is entirely compromised and the wood surface has begun to disgregate.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Death Valley National Park, Death Valley, CA

The climate of Death Valley is hot and dry.

Wood and historic finishes are deteriorated as the result of exposure to the desert climate.

Finish deterioration is characterized by yellowing, loss of elasticity, incremental mechanical failure, detachment

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DAMAGE TYPOLOGY: SUBSTRATE

SURFACE EROSION	
Exposure to UV light results in the breakdown of the lignin matrix of wood, resulting in a loss of surface coherence, increased friability, and erosion. Earlywood is especially susceptible to erosion, and the process is often accompanied by detachment of wood fibers that appear as little "hairs" on the wood surface. In Fig. 1, wood surfaces exposed to sunlight are noticeably eroded while shaded surfaces are smooth and largely intact. Under magnification, damage to the wood structure and disgregation of wood fibers from the surface are evident (Fig. 2). In Fig. 3, erosion is pronounced around the system of small checks that has developed on the end grain, as well as along earlywood layers of the wood surface.	 Fig. 1  Fig. 2  Fig. 3

Weathering of wood is characterized by chromophoric (color) changes at the surface.

As the lignin is changed by exposure to light, the chemical byproducts are chemically unstable and dissolve readily in water.

Small amounts of water are enough to wash away the deterioration products on the surface, exposing new wood to light so that the process continues.

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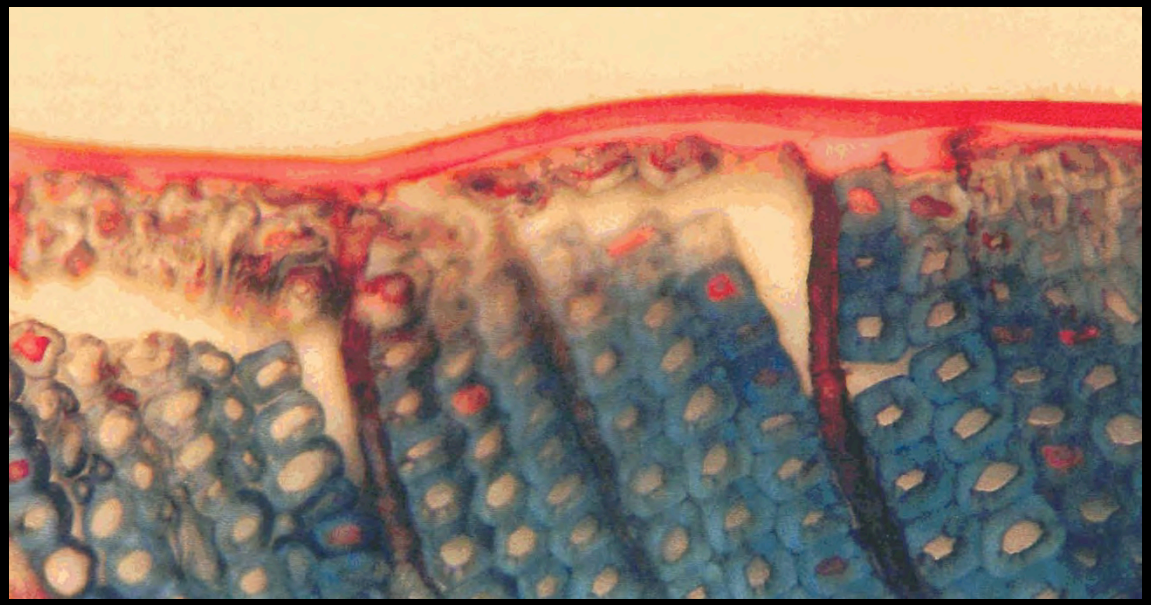
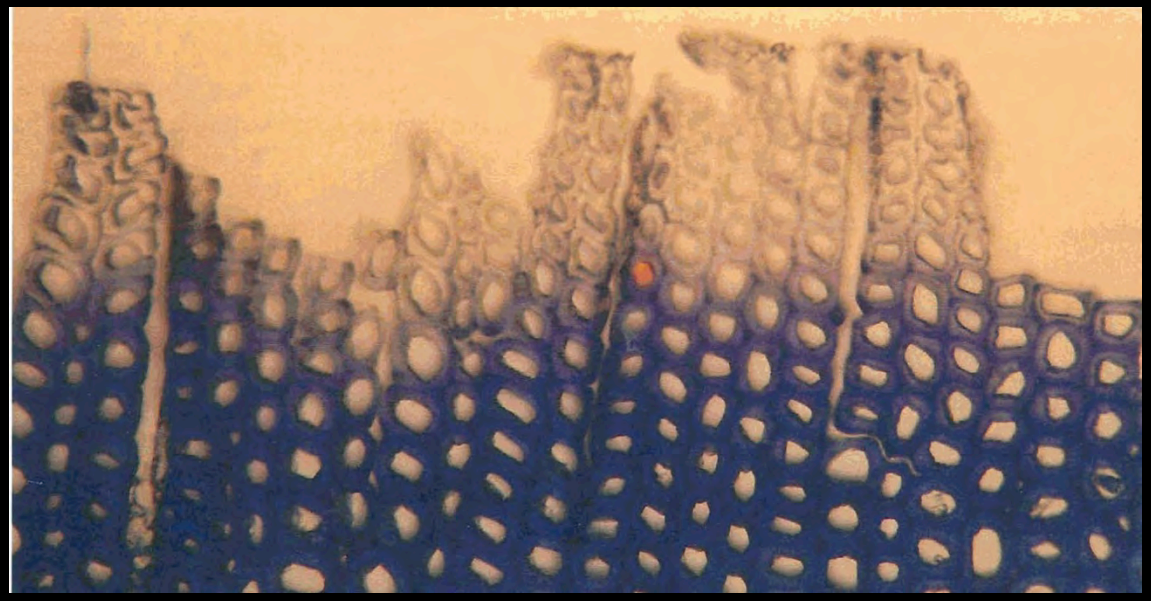
Deterioration of the coating and the substrate occur simultaneously. Varnish detachment and loss:

A.The lignin is degraded through the clear coating and the surface begins to disgregate (top)

B.The coating is lost along with many of the deteriorated cells (bottom)





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Finishes analyses indicate that most of the woodwork at Scotty's Castle was coated with spirit varnishes (copal, dammar) and seemed to have been maintained with linseed oil.

Over time, linseed oil dries and polymerizes. It becomes inelastic, is difficult to remove, provides no light protection, is not light stable itself, and can attract mildew and other molds.

Treatment resins should:

- Be synthetic rather than natural
- Function as consolidants for the wood and the existing finishes
- Be film forming
- Have good photostability and provide light protection to the wood
- Have minimal impact on appearance
- Be reversible or, at minimum, retreatable

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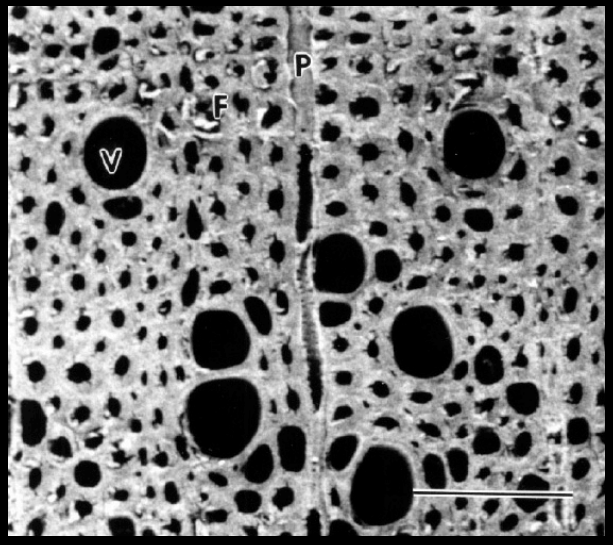
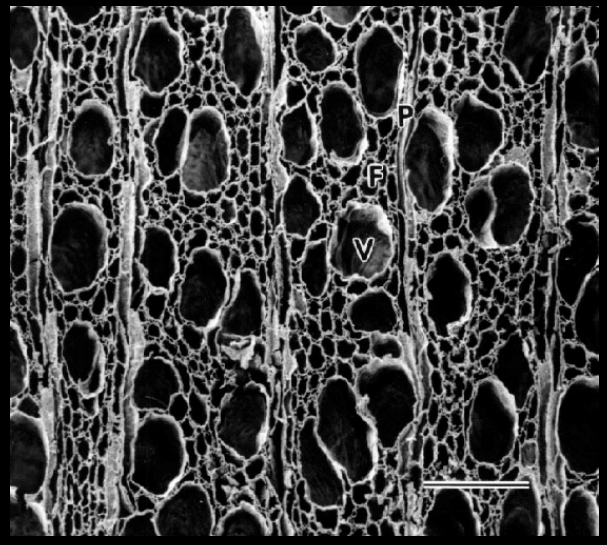
Several strategies exists for the clear or semitransparent finishing of wood including:
- Consolidant treatment to improve surface resistance to weathering
- Use of inorganic pigments (semi-transparent deck stains) that absorb
- The addition of UV stabilizers to clear coatings

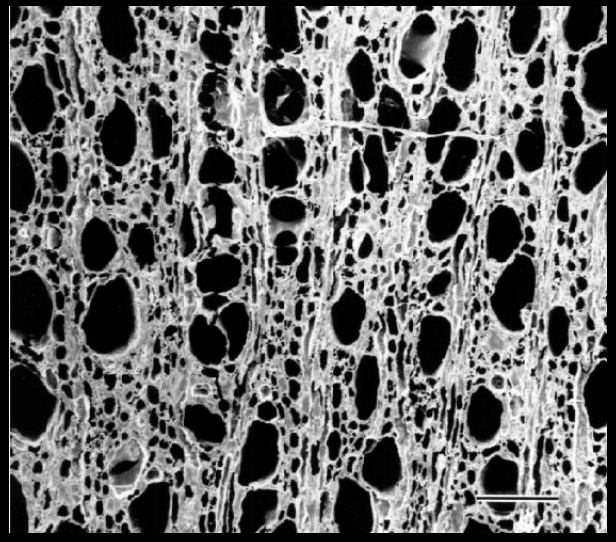
Stabilizers in these finishes include absorbers that convert light energy to caloric energy or heat, and HALS that trap radicals formed by photo-degradation. In this project proprietary finishes were tested, as was Butvar B-98 (a polyvinyl butyral used primarily in object conservation applications for its mechanical properties, depth of penetration, light and heat stability, and reversibility/re-treatability).



Healthy cell structure



Weathered & deteriorated cell structure


Consolidated with B-98

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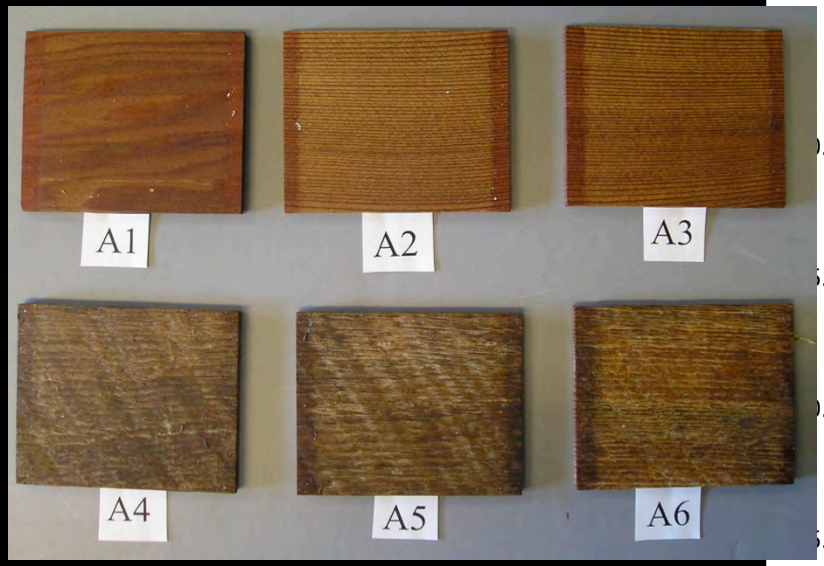
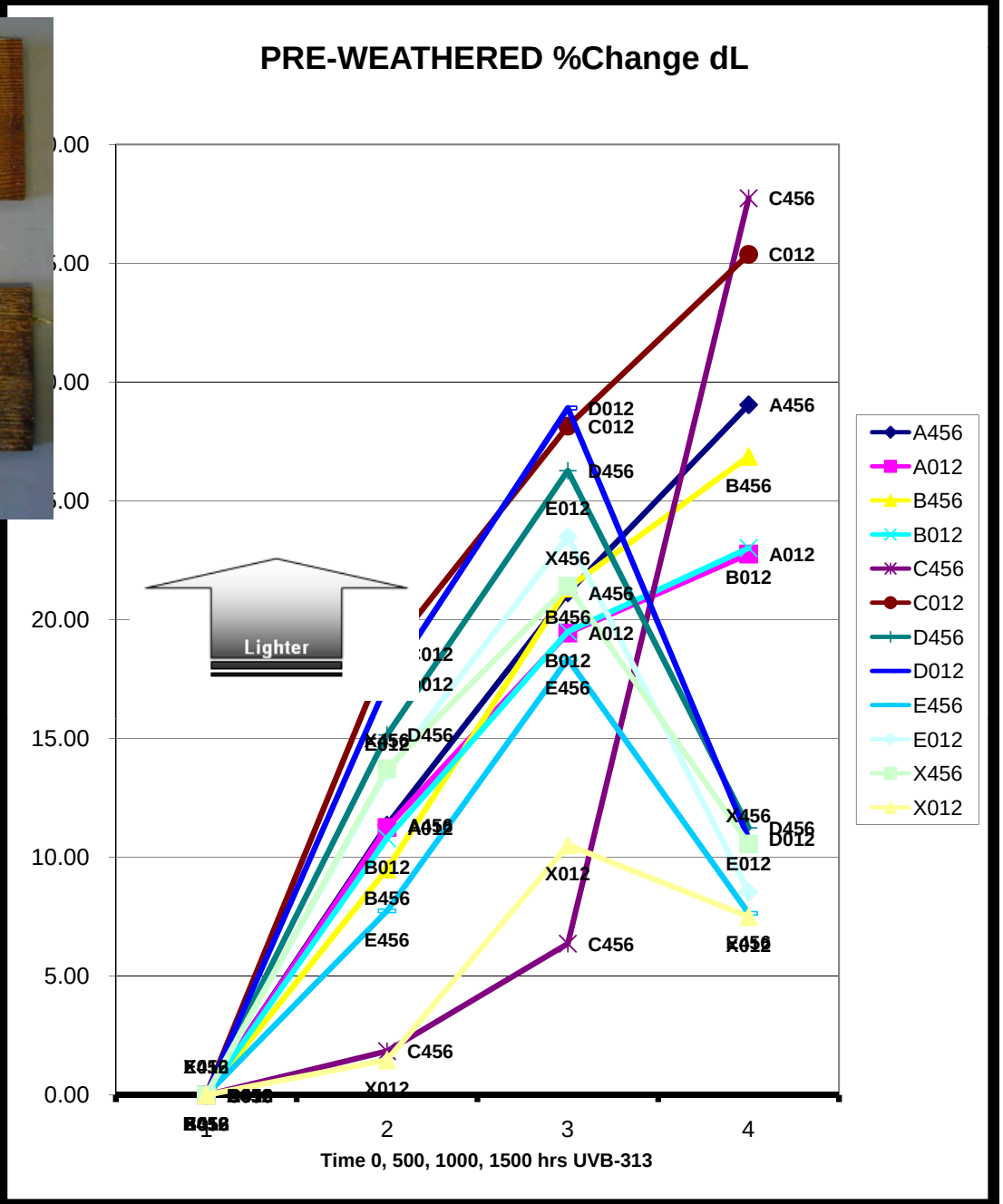


A number of finishes were subjected to natural and accelerated weathering. While all provided some level of light protection, B-98, amended with a UVA / HALS blend, was one of the highest performers.

Ultimately, B-98 became the consolidant of choice due to its known performance properties.



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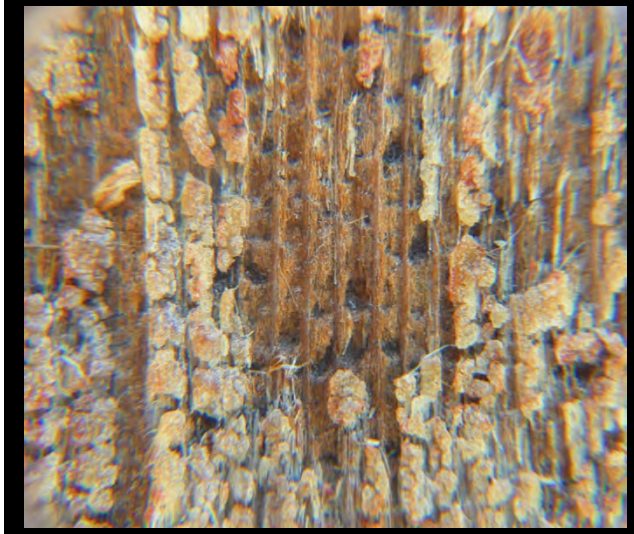
At Scotty's Castle, where the existing coating(s) had failed completely, application of the consolidant resulted in visible improvement of the surface.

Dry cleaning (with a nylon-bristle brush) left a surface relatively free of old varnish, but disgregated as the result of UV exposure.

The consolidant treatment resulted in the binding of detaching wood fibers to the surface. Note that the surface displays preferential erosion of earlywood layers.



Before varnish removal

During varnish removal

After consolidation

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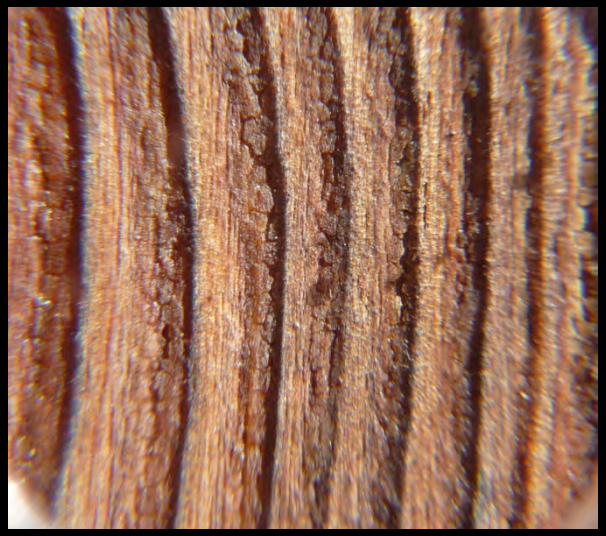
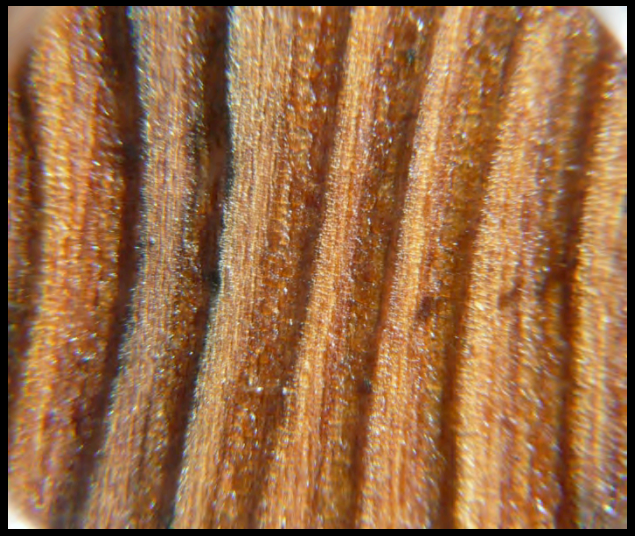
In the early stages of failure, embrittled coatings develop cracks that admit water to the substrate, promoting dimensional instability associated with changes in moisture content, and subsequent detachment of the coatings.

The consolidant fills these cracks, reducing moisture infiltration.

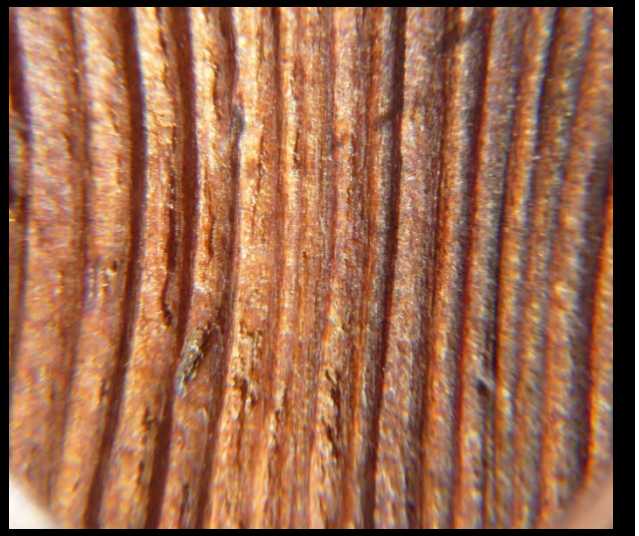
The consolidant can be effectively removed without adversely affecting the existing coatings by carefully selecting solvents (for mixing and cleaning) that do not dissolve the original varnish(es).



Before consolidation



After consolidation



After B-98 removal

Treatment Procedures: Cleaning

1. Dry Brushing

Remove loose varnish and debris with a coarse, nylon bristle brush. Brushing should be in the direction of the grain.

2.Acetone Spray*

Remove loose varnish that does not come off readily with a brush by applying acetone through a low-pressure spray bottle. Once the acetone has dried, brush away the varnish with a nylon brush. Again, brush in the direction of the grain. Repeat as necessary.

**This method of cleaning is only appropriate where the existing finish has failed and must be removed entirely.*

Treatment Procedures: Cleaning

3. Acetone Solvent Gel

Where heavy varnish won't come off with brushing or acetone spray, gel provides a means for increasing the dwell time of the acetone on the surface without penetrating the wood.

This type of cleaning should not be done in direct sun.

Apply a thick layer (1/4") of the gel with a spatula or brush. Leave until varnish easily separates from the substrate (1-2 hours). Keep gel moist while in place by either misting frequently with water or covering with plastic wrap.

Treatment Procedures: Cleaning

Remove gel with running water and/or wet sponge, as feasible. Collect any runoff. Wet wood is vulnerable: do not scrape or gouge the surface. Be sure to remove all gel entirely before proceeding to next step.

When all gel has been removed, allow element to dry completely. Then, with a nylon-bristle brush, brush away wood fibers released during varnish removal. Brush in the direction of the grain. Do not brush wood when wet, as this will result in damage.

Treatment Procedures: Cleaning

Acetone Solvent Gel

- 20g Carbopol 934
- 70 ml Ethomeem C 25
- 1000ml acetone
- 160ml water

A. Mix the Carbopol 934 and Ethomeem C 25 together quickly to completely wet the Carbopol 934 and remove lumps

B. Add the acetone and shake until thoroughly mixed

C. Add water incrementally (30 ml at a time) and shake vigorously until the desired consistency is achieved.

Treatment Procedures: Cleaning

4. Wet Cleaning

Loose embedded dirt, bird droppings, mildew and other accretions can be removed with water and a coarse nylon-bristle brush used in the direction of the grain. To remove mildew, use a 2% Vulpex solution in water and rinse thoroughly.

Treatment Procedures: Consolidation

Make sure surface is free of dust, debris and loose fibers. Dry-brush bare wood or vacuum/sponge varnished surfaces.

Cut in any hardware using a trim brush. Any B-98 that is inadvertently applied to metal hardware can be removed with ethanol.

Coat the wood evenly with the consolidant. Add a heavier application to any areas that are particularly dry.

Allow B-98 to dry for 30 minutes before applying the second coat.

Treatment Procedures: Consolidation

Consolidant: 3.5% B-98 (g/ml) in Ethanol (ETOH) w/ 8% Tinuvin 5151 by vol of B-98

- B-98 260ml (or 70g)
- Ethanol (ETOH) 2000ml
- Tinuvin 20.8ml

A. Add dry B-98 slowly to ethanol (ETOH) and mix thoroughly (do not let the B-98 clump)
B. Allow to sit for 30 minutes
C. Add Tinuvin and mix thoroughly.

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In considering the feasibility of using the treatments described in this report in other contexts, it is important to recall the process architectural conservators followed in designing the treatments, and to apply them appropriately to different sites with different materials and conditions. It should not be assumed that the treatments developed here can be uniformly applied at any site. Instead any treatment at future sites should be preceded by:

- Condition assessment, to understand the deterioration conditions that candidate treatments will need to address
- Finishes analysis, to determine which of the existing finishes are to be preserved
- Resin selection, to select treatment products that will address deterioration without compromising historic finishes
- Treatment testing, to determine whether and how treatments can be applied to minimize adverse impacts to historic materials
- Pilot testing, to solve problems posed by field implementation of the treatments and to establish the desired treatment aesthetic