The Alberta Shake Development Program

Final Report

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Submitted By:

The Lac La Biche
Regional Economic Development Council
Lac La Biche, Alberta

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ABSTRACT

A research and development program was initiated by the Regional Economic Development Authority in Lac La Biche to investigate jack pine (*Pinus banksiana*), aspen (*Populus tremuloides*), and lodgepole pine (*Pinus contorta var. latifolia*) as candidate species for use in roofing shakes. Dimensional stability and the significance of defects were investigated through the use of a 14-week rain test (accelerated weathering), as well as through field trials. A 60-month outdoor exposure field trial program has been initiated.

This study concluded that jack pine would perform the best as a shake. Both jack pine and lodgepole pine would perform very well if shake quality was maintained. It was concluded that aspen should not be developed as a source species for roofing shakes at least until more conclusive field trial results are available.

Numerous recommendations of a technical and a strategic nature are presented for prospective shake manufacturers.

1.0 INTRODUCTION

Shake production from Alberta wood species has the potential to be a high value-added, good employment sector of the Lac La Biche regional economy. This project provides the "kick off" for the Alberta Shake Development Program which will assist in the establishment of a shake industry based on Alberta pine. Benefits from the Alberta Shake Development Program are expected to flow to all of Alberta's forested regions, but development is expected first in the Lac La Biche region.

This project was sponsored by the Regional Economic Development Council (REDC) of Lac La Biche. The REDC is a non-profit community group which promotes the development and diversification of the Lac La Biche regional economy. Funding for the project was provided by the Canada/Alberta Forest Resource Development Agreement and the REDC. Silvacom Ltd., an Edmonton based forestry and forest products consulting company, was retained to undertake the technical work involved in establishing the Alberta Shake Development Program.

Jack pine (*Pinus banksiana*) and aspen (*Populus tremuloides*), which are native to the Lac La Biche region, and lodgepole pine (*Pinus contorta var. latifolia*), which is native to many of the other forested regions of Alberta, are being considered as source species for taper-sawn shakes in Alberta. As the supply of old-growth western red cedar continues to dwindle, alternative species of more readily available trees such as pine and the northern hardwoods are now being investigated for use by the shake industry.

Previous research and development work sponsored by the REDC and the Canada/Alberta Forest Resource Development Agreement revealed that a thin shingle (i.e. less than 1/2" thick at the butt) manufactured from jack pine or aspen would not perform satisfactorily. The current work centered around the taper sawn shake concept. Taper sawn shakes are generally 3/4", or thicker, at the butt end of the shake.

Lodgepole pine, jack pine and aspen shrink more when dried from green volume to ovendry weight than does western red cedar. This is of special interest with respect to shakes because these products frequently cycle between saturation and very low moisture contents. Repeated shrinking (as wood dries below fiber saturation) and swelling (as wood is rewetted by rain) could result in warping, checking or splitting of shakes. Nevertheless, the radial shrinkage values for these species, though greater than those of western red cedar, are slightly less than those of the southern pines (Table 1), which have been used very successfully as shakes. With respect to dimensional stability, aspen, jack pine, and lodgepole pine seem to have potential as source species for shakes. A major goal of the current project was to investigate the dimensional stability of these species in greater detail, particularly as affected by variations/defects in shake construction (such as flat grain, knots, thickness, etc.). In other words, would the dimensional stability of these species allow them to perform adequately as roofing shakes? What defects were significant to the performance of these species? What defects could be tolerated?

Unlike western red cedar, the heartwood of aspen, jack pine and lodgepole pine have little or no resistance to decay. Thus, where decay hazards exist, some form of preservative treatment will be necessary. For mild decay conditions, a simple short soak in preservative after manufacture should be adequate for wood low in decay resistance. Another major goal of this project, therefore, was to evaluate a simple dip treatment for its preservative effects.

Besides sponsoring the R&D program as outlined above, this project sought to assist prospective manufacturers in the establishment of a viable shake industry. To that end, recommendations have been made to manufacturers in the Lac La Biche region regarding quality specifications and control, marketing strategies, inspection and certification strategies, etc. This report details the findings of the R&D program and highlights the recommendations made to prospective manufacturers in the Lac La Biche region.

TABLE 1. SHRINKAGE VALUES OF SPECIES EVALUATED FOR WOOD ROOFING

Species	Shrinkage from Green to Ovendry Content Moisture Content Expressed as Percentage of the Green Dimension		
	Radial (%)	Tangential (%)	Volumetric (%)
Western red cedar	2.4	5.0	6.8
Loblolly pine	4.8	7.4	12.3
Longleaf pine	5.1	7.5	12.2
Shortleaf pine	4.6	7.7	12.3
Slash pine	5.4	7.6	12.1
Aspen	3.5	6.7	11.5
Lodgepole pine	4.3	6.7	11.1
Jack pine	3.7	6.6	10.3

Source: Wood handbook: Wood as an Engineering Material. USDA Handbook 72.

2.0 OBJECTIVES

The principal goal of the current project was to investigate the dimensional stability of aspen, jack pine, and lodgepole pine, particularly as affected by variations/defects in shake construction (such as flat grain, knots, thickness, etc.). In other words, would the dimensional stability of these species allow them to perform adequately as roofing shakes? What defects were significant to the performance of these species? What defects could be tolerated?

A second objective was to determine the merits of improved decay and insect resistance through low cost, non-pressure treatment (dip treatment) with an aqueous solution of copper napthenate wood preservative (Cunapsol).

Besides sponsoring the R&D program, this project sought to assist prospective manufacturers is the establishment of a viable shake industry in the Lac La Biche region. To this end, an additional project objective was defined as the provision of technical and marketing assistance to manufacturers in the Lac La Biche region regarding quality specifications and control, marketing strategies, inspection and certification strategies, etc.

3.0 METHODS

3.1 Plan

The plan called for shipping aspen, lodgepole pine and jack pine taper-sawn shakes to the Texas Forest Products Laboratory of the Texas Forest Service in Lufkin, Texas, for testing.

The shakes were shipped "green" to enable laboratory personnel to treat the shakes in both a wet and dry condition. Upon arrival, the shakes were to be divided into two groups; those to be treated green and those to be treated following kiln drying.

The shakes were to be dipped in a 1% Cunapsol (water borne napthenate) solution for 24 hours. Following treatment, the shake bundles were to be stacked and allowed to dry for a minimum of 10 days prior to installation on the test decks.

Two groups of panels were to be constructed using the treated and untreated shakes. One group was to be placed outside for long term exposure (60 months), whereas the other group was to be placed in an accelerated weathering apparatus (14-week rain test) and their performance and preservative durability evaluated.

3.2 Shake Manufacture

The taper-sawn shakes manufactured in Alberta for this study were 24 inches long, had widths ranging from 4 to 8 inches and butt thicknesses of 3/4" to 1 1/4". The shakes were manufactured from nominal 2" lumber rather than being sawn on a conventional shingle saw. Because of variations in the source of supply, the lodgepole pine shakes were considerably thinner than the aspen and jack pine shakes (3/4" thick at the butt for lodgepole pine compared to over 1" thick at the butt for aspen and jack pine). The shakes were essentially all flat grain and contained knots and other visible defects. Cedar and southern pine shakes, on the other hand, are essentially knot-free and every effort is made to minimize the amount of flat grain which normally can cause splits and warpage upon exposure. Figures 1 and 2 show some of the green lumber and shake bundles manufactured for this project.

Western red cedar shakes and shingles were included in the study as the "industry standard". These shakes were purchased from commercial sources in Texas. Taper sawn shakes from Western red cedar were not available, so handsplit-resawn shakes (3/4 " heavies and 1/2" mediums) were substituted. (See Table 2).

TABLE 2. WOOD ROOF COVERINGS EVALUATED IN 14 WEEK RAIN TEST AND LONG TERM (60 MONTH) FIELD EXPOSURE.

Deck No.(1)	Description
1	Jack pine, untreated
2	Jack pine, dipped green
3	Jack pine, dipped dry
4	Lodgepole pine, untreated
5	Lodgepole pine, dipped green
6	Lodgepole pine, dipped dry
7	Aspen, untreated
8	Aspen, dipped green
9	Aspen, dipped dry
10	Western red cedar (2,3) shingles, untreated
11	Western red cedar (3) medium handsplit-resawn shakes, untreated
12	Western red cedar (3) heavy handsplit-resawn shakes, untreated

NOTE:
(1) All shakes installed over spaced decking at 10 inch exposure using the 30 lb. felt interlay system.
(2) Cedar shingles installed at 5 1/2" exposure with no felt interlayment.
(3) These shakes/shingles evaluated in previous 14-week rain tests in 1988-1989.

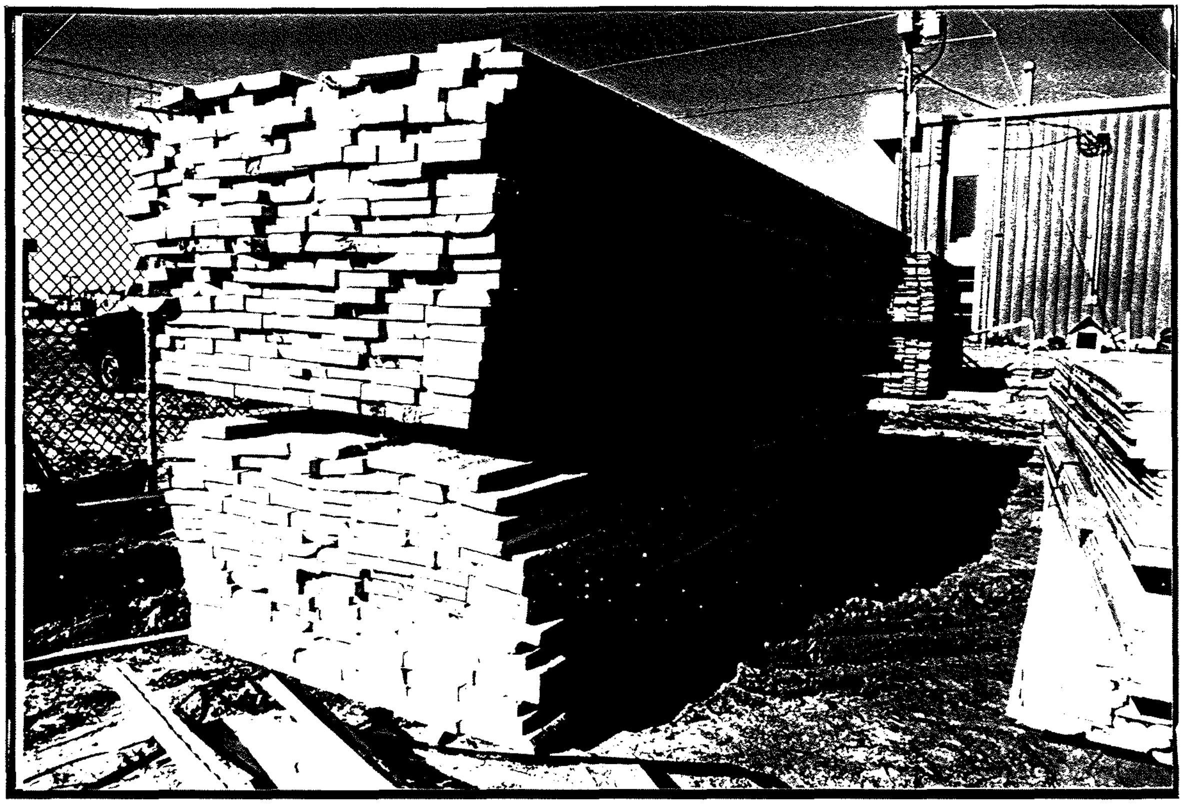


Figure 1. Jack pine (top) and aspen (bottom) lumber prior to manufacture into shakes.

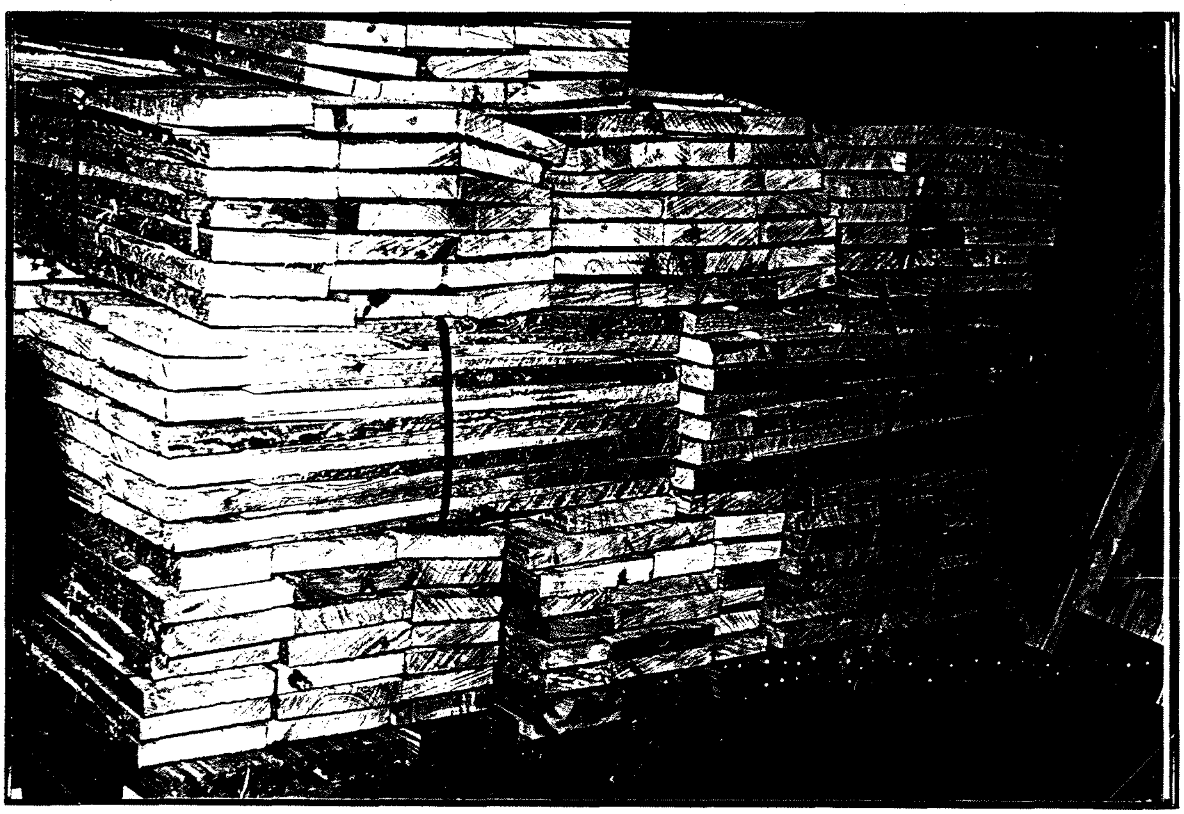


Figure 2. Taper sawn shakes ready for shipment to Texas Forest Products Laboratory.

3.3 Preservative Treatment - Cunapsol

A predetermined number of freshly sawn aspen, jack pine and lodgepole pine shakes were shipped to the Texas Forest Products Laboratory in June, 1989 (approximately 30 bundles). The shakes were essentially "green" with moisture contents ranging from 52% to 139%. The average moisture content for the aspen shakes was 118%, 69% for the jack pine and 99% for the lodgepole pine. Although the shakes had been packed in mothballs to prevent sapstain or other contamination, some bundles (particularly the lodgepole pine and aspen) had evidence of sapstain and surface mold.

Half of the shake bundles were selected, at random, for preservative treatment in a 1% Cunapsol solution. The remaining bundles were placed in a conventional dry kiln at 140° F and allowed to dry to a moisture content of 19% or less.

A special dip tank was constructed to allow lab personnel to treat four bundles of shakes at one time. The green shake bundles were placed under continuous water spray to prevent drying prior to treatment. The shake bundles were weighed before and after the 24-hour dip in the 1% Cunapsol solution in order to determine the amount of preservative picked up by the shakes.

The variations in moisture content of the green shakes prevented uniform chemical pick up as determined by weight gain analysis. The most accurate method to determine actual retentions of the copper napthenate (Cunapsol) would be through atomic absorption analysis. These results will be discussed later in this report.

Following the 24-hour dip treatment in the copper napthenate solution, the shake bundles were stacked in groups of 8-10 bundles to simulate storage on pallets. The shake bundles were stored indoors out of direct exposure to rainfall or sunlight (minimum 10 days). Dip treatment of the "green" shake bundles was completed

June 16, 1989. The dip treatment of those shake bundles which had been kiln dried was completed the following week.

3.4 Test Deck Construction

Test decks for both studies were constructed at the Texas Forest Products Laboratory in June, 1989. The test decks [3 1/3' (1.0m) x 4 1/3' (1.3m)] were constructed according to ASTM Standard 108, paragraph 5, "Standard Method of Fire Tests of Roof Coverings".

The decks were constructed of nominal 1" x 4" Southern pine lumber spaced 1 5/8" (4cm) apart, and securely nailed to two nominal 2" x 4" wood battens. Shakes were fastened to the decks with No. 6 common, hot-dipped galvanized nails; shakes were applied from left to right within each row.

3.5 Shake Panel Construction

Following air drying (minimum 10 days) the shake bundles were segregated by species and shakes were picked at random to be installed on the test decks.

A total of 24 test panels were constructed. Twelve decks were exposed to the accelerated weathering test (14-week rain test) and a duplicate set of test panels was placed outside for long-term field exposure.

3.6 Accelerated Weathering

3.6.1 14-Week Rain Test

A 14-week rain test was initiated in July of 1989, at the Texas Forest Products Laboratory in Lufkin, Texas. Candidate shakes plus reference materials (cedar roofing) were installed on decks and subjected to alternating wetting and drying cycles in accordance with procedures defined in Underwriters Laboratory (UL

Standard 790) alternative 14-week rain test. This procedure allows for simultaneous accelerated rain testing of two sets of six test panels each. Each test panel was exposed to seven days of continuous rain, 2 days of draining at ambient conditions, and five days of drying in a kiln at 140° F (60° C). This cycle was repeated seven times, which is one more cycle than required by ASTM D-2898. Well water was used in the wet cycles.

3.6.2 Evaluating Shakes for Stability

During each test, two six-deck sets of shakes were alternated between wetting and drying facilities. At the end of the first, third, fifth and seventh cycles the shakes were inspected for evidence of cupping, curling, bowing, checking and splitting (see Appendix A). *Curling* results when a concave bend lifts the butt end from the roof deck (snowshoe effect). *Cupping* occurs when one or both sides of the shake lift up (the center of the shake can still lie in its original position on the deck). *Bowing* is the reverse of cupping. *Checks* are small vertical fissures that develop on the surface and penetrate into, but not through, the shake. *Splits*, by contrast, are vertical fissures extending through the entire thickness of the shakes.

For each test panel, the percentage of shakes showing the following defects were computed:

- Displacement in excess of 0.5 inches due to curling and 0.25 inches due to cupping and bowing.
- Grain separations, major and minor splits.
- Checking.

For a more detailed explanation of how these measurements were taken, see Appendix A (Evaluation Methods and Criteria).

3.6.3 Chemical Analysis

Six shakes from each group of treated shakes were selected at random from the bundles (prior to installation) to be analyzed for Cunapsol retentions. Additional sets of shakes were installed on special decks that were subsequently weathered alongside the larger test panels in the 14-week rain test.

Following accelerated weathering the treated shakes on the mini panels were removed and analyzed for Cunapsol (copper napthenate) using the atomic absorption method. Results from the analysis of both unweathered and weathered Cunapsol treated shakes will be discussed in the next section.

3.7 Long-Term Field Exposure Test

The 14-week rain test began in July, 1989, and was completed in November, 1989. Those test panels intended for outdoor field exposure were installed at the Hudson Research facility near Lufkin in August, 1989. These shakes will be inspected for stability, insect and decay attack in August, 1990, and every August thereafter for four more years. Duration of this test is 60 months (5 years).

Figures 3 and 4 illustrate two test roofs installed August 15, 1989 at Lac La Biche, Alberta. One roof is untreated jack pine, the other is jack pine dipped green in Cunapsol. Additional test roofs are scheduled to be installed in 1990.

Figure 3. Test roof at Lac La Biche. Untreated jack pine. Installed August 15, 1989.

Figure 4. Test roof at Lac La Biche. Jack pine - dipped green, Cunapsol. Installed August 15, 1989.

4.0 RESULTS - ACCELERATED WEATHERING

4.1 Dimensional Stability - 14-Week Rain Test

A total of nine test decks were subjected to accelerated weathering in the 14-week rain test. This test consists of seven days of rain followed by two days draining and five days drying at 140° F to a moisture content below 6%. This cycle was repeated seven times.

The data from the cedar shake and shingle groups was obtained by averaging the results from three previous test runs for use as an industry standard control group.

The procedure used to evaluate the test decks following completion of the 14-week test is described in detail in Appendix A. This procedure was developed in cooperation with the U.S. Forest Products Laboratory for use in similar studies in which several other alternative species were evaluated for use as roofing.

Figures 5 through 11 are graphic representations of the seven different defects that were measured in this test for each group. Although some of these "defects", such as cupping, may not be detrimental to the function or perhaps even the appearance of a roof, they are a quantitative measure of the relative dimensional stability of these test shakes versus the industry standard, western red cedar.

Curling did not occur to any significant degree. In fact, the medium cedar shakes fared the worst.

Cupping was considerable. At least one in three shakes cupped to a measurable degree. Bowing was also significant, but to a lesser degree. The vast majority of non-cedar shakes either cupped or bowed, few remained perfectly flat. Bowing was more pronounced in the untreated shakes.

Surface checking was rather high compared to cedar. However, it should be pointed out that cedar is a remarkably stable wood that resists checking as well as the other defects. Other alternative roofing species have shown similarly high amounts of checking compared to cedar.

While checking itself is not a serious defect, it is cause for concern because the forces that cause checks can cause more serious defects such as splits. Indeed, a deep check will often develop into a split.

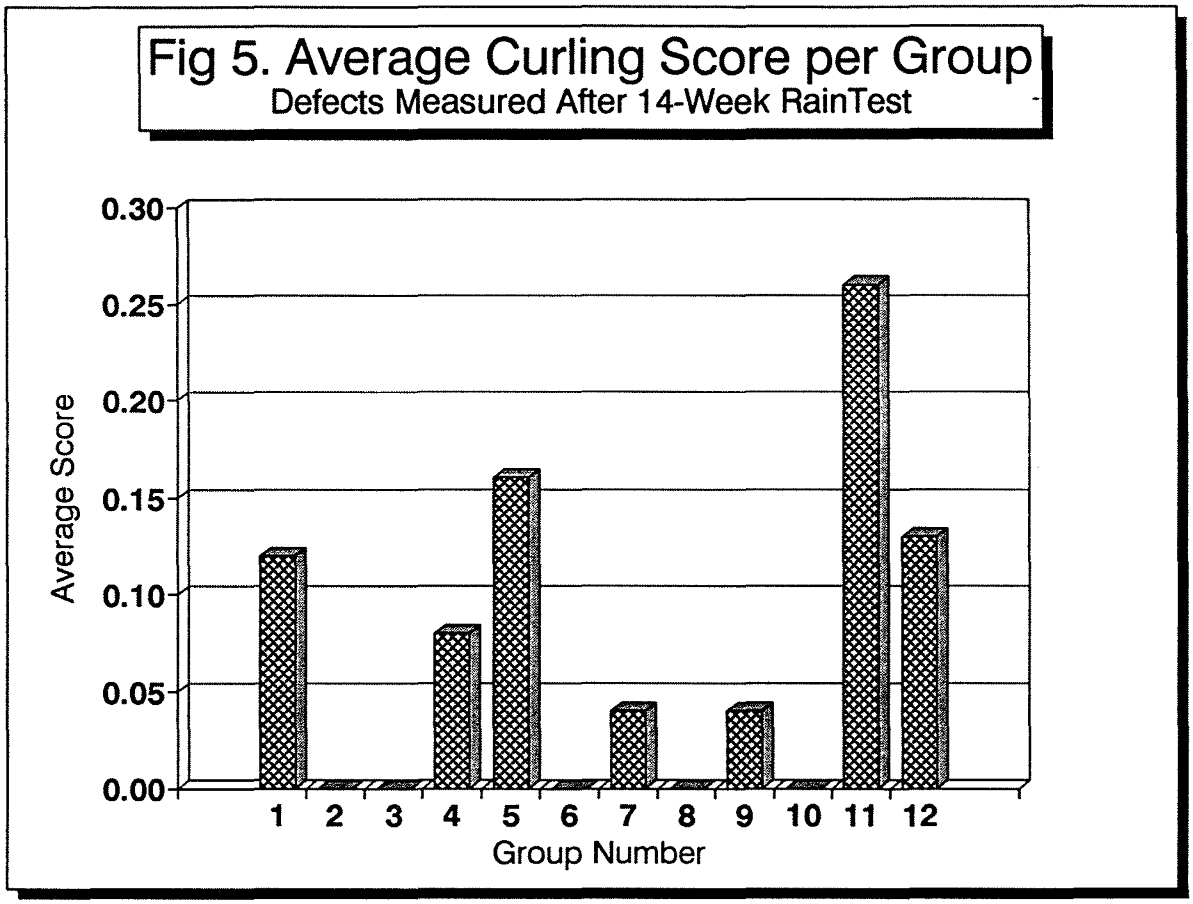
Grain separations are a serious defect because they can develop into a major split. They were considerably less pronounced in the jack pine shakes than in the lodgepole pine and aspen shakes. The greater thickness of the jack pine may have contributed toward this higher stability.

Minor splits may or may not worsen into major splits, but they are indicative of the species' tendency to split. All three species were considerably higher in minor splits than cedar.

Major splits were not a problem with the possible exception of group 8, aspen dipped green.

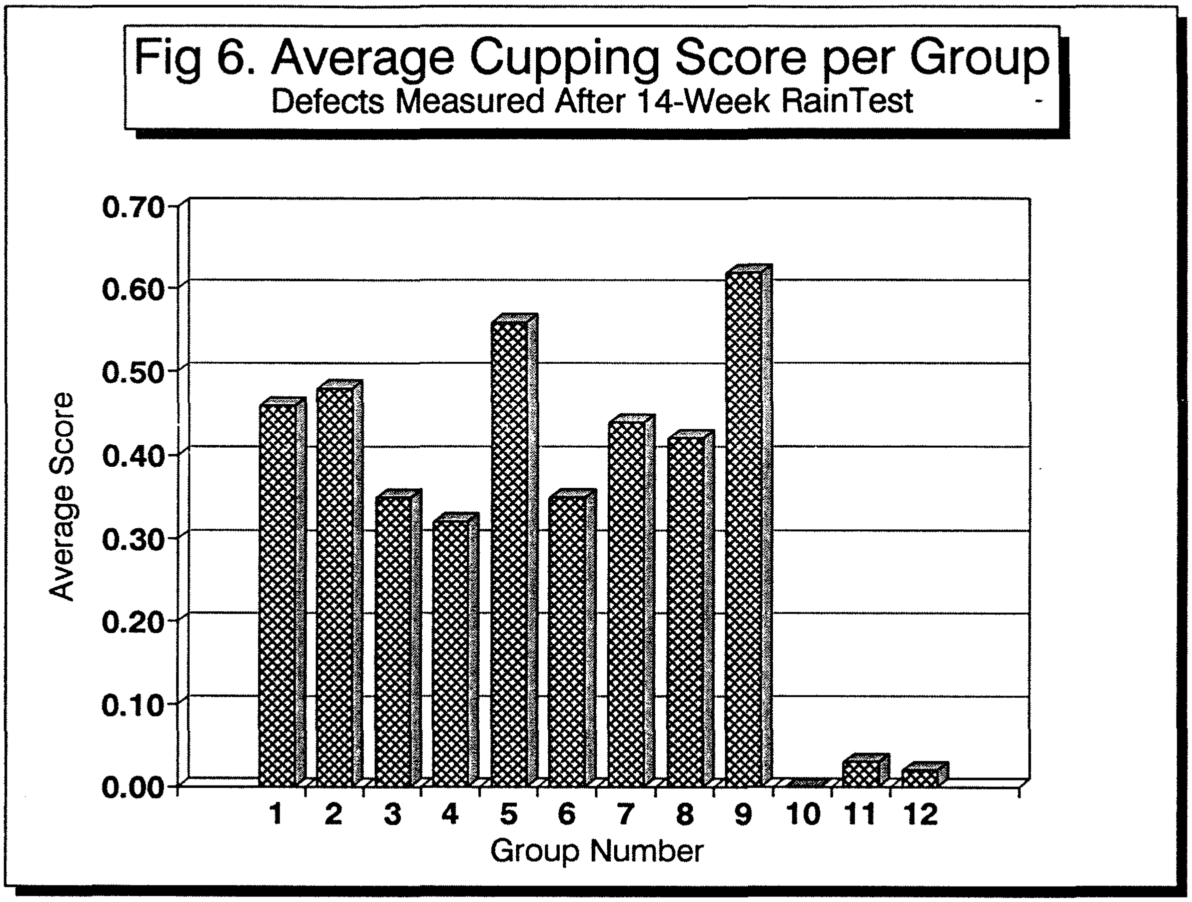
Although outdoor exposure data is needed to draw more meaningful conclusions, a few comments are warranted at this stage.

Dimensional stability of the jack pine, lodgepole pine, and aspen shakes is not comparable to cedar shakes or shingles. They were not expected to be so. However, cedar is a very stable wood and an alternative species need not mimic its performance to be useful as a roofing material. The three species under consideration performed reasonably well considering the amount of flat grain contained in them.



GROUP DEFINITION

1 Jack Pine - Untreated	7 Aspen - Untreated
2 Jack Pine - Dipped Green	8 Aspen - Dipped Green
3 Jack Pine - Dipped Dry	9 Aspen - Dipped Dry
4 Lodgepole Pine - Untreated	10 Cedar Shingles
5 Lodgepole Pine - Dipped Green	11 Cedar Shakes - Medium
6 Lodgepole Pine - Dipped Dry	12 Cedar Shakes - Heavy



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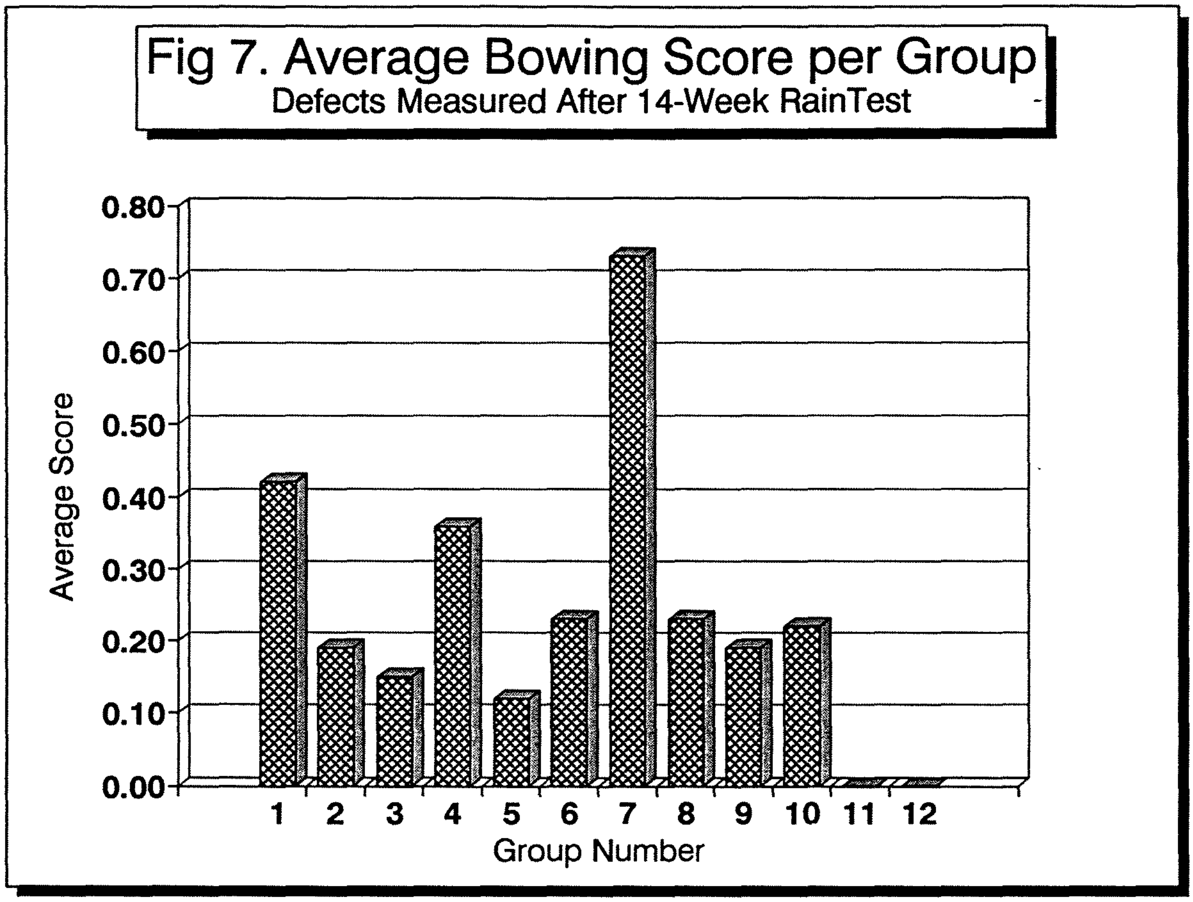

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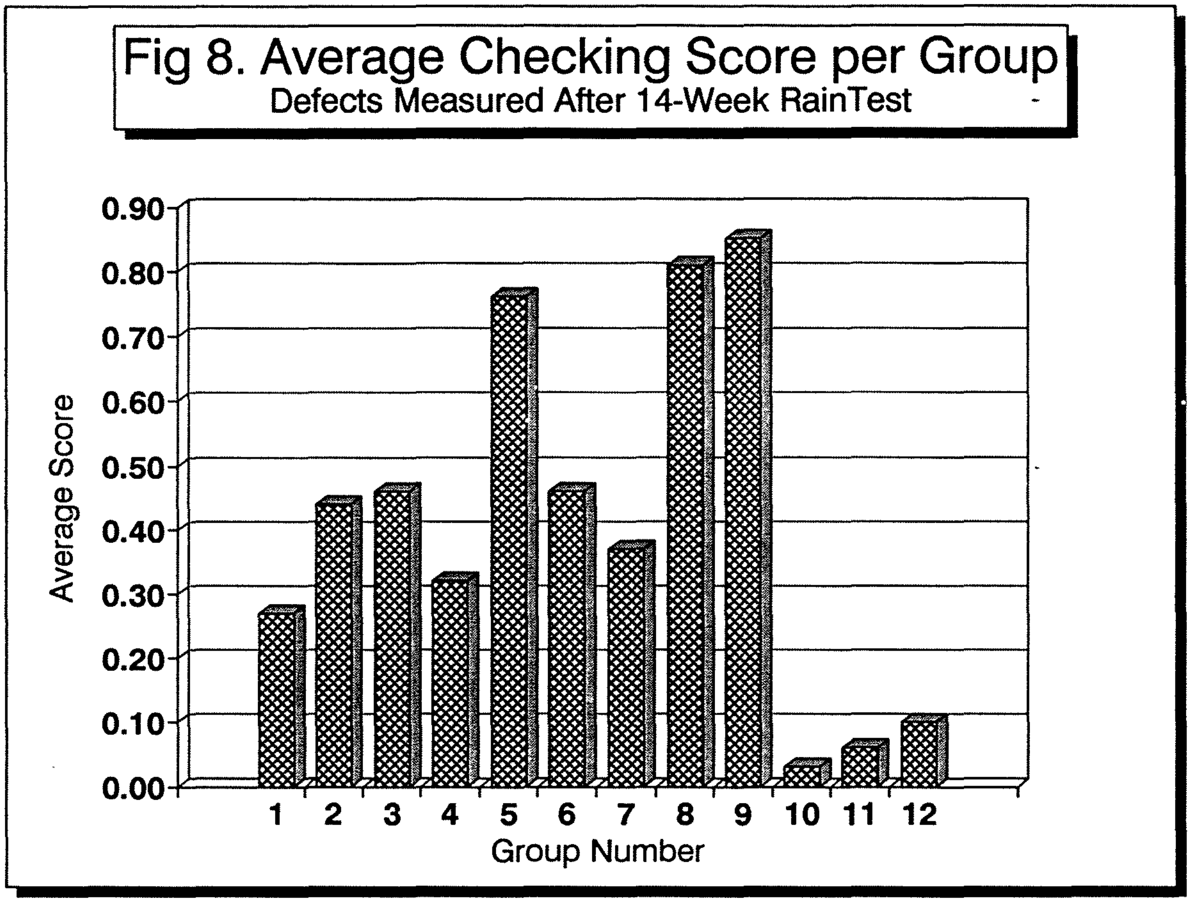

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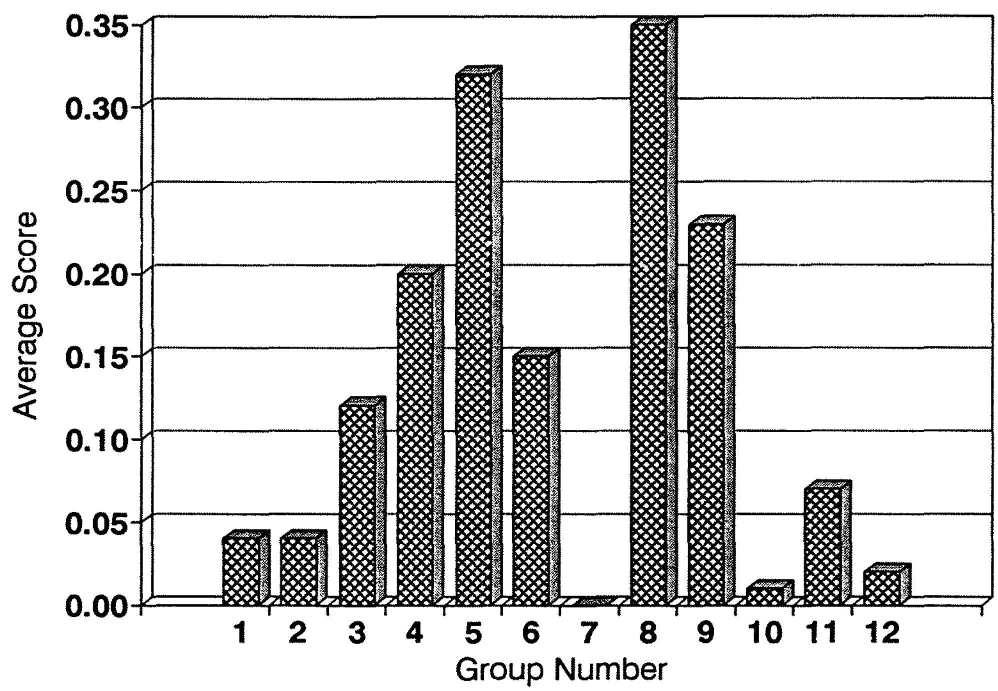
Fig 9. Average Grain Separation Score
Defects Measured After 14-Week RainTest



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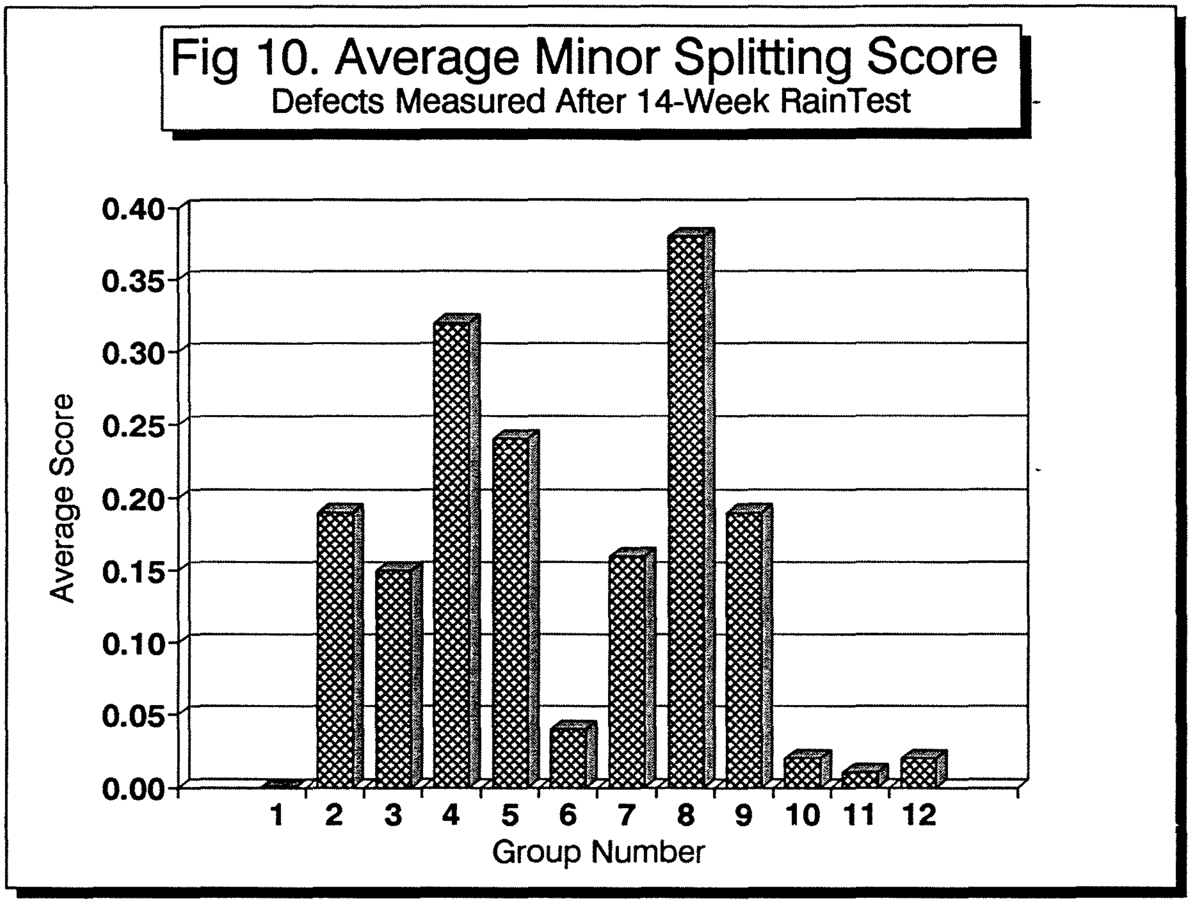
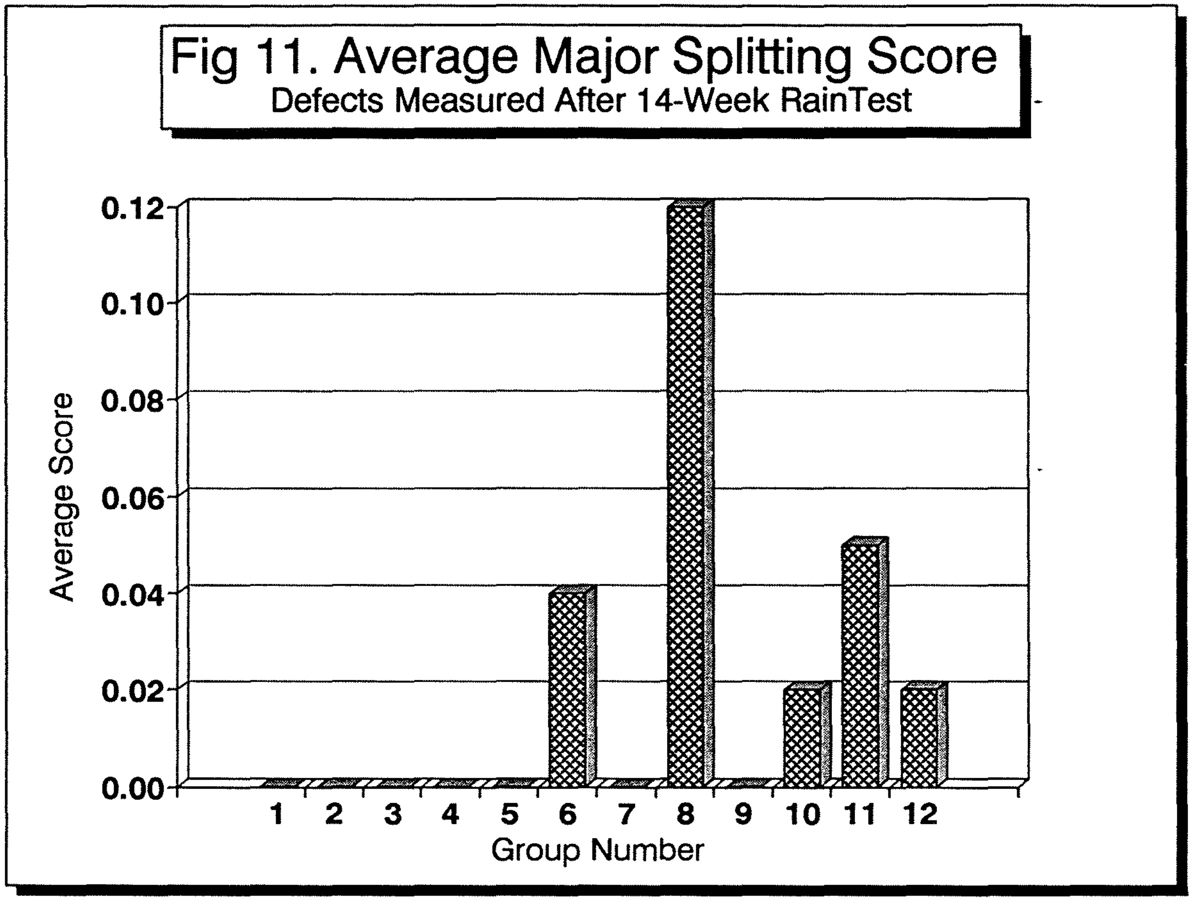
3 Jack Pine - Dipped Dry	9 Aspen - Dipped Dry
4 Lodgepole Pine - Untreated	10 Cedar Shingles
5 Lodgepole Pine - Dipped Green	11 Cedar Shakes - Medium
6 Lodgepole Pine - Dipped Dry	12 Cedar Shakes - Heavy



GROUP DEFINITION

1 Jack Pine - Untreated	7 Aspen - Untreated
2 Jack Pine - Dipped Green	8 Aspen - Dipped Green
3 Jack Pine - Dipped Dry	9 Aspen - Dipped Dry
4 Lodgepole Pine - Untreated	10 Cedar Shingles
5 Lodgepole Pine - Dipped Green	11 Cedar Shakes - Medium
6 Lodgepole Pine - Dipped Dry	12 Cedar Shakes - Heavy



GROUP DEFINITION	
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6 Lodgepole Pine - Dipped Dry	12 Cedar Shakes - Heavy

Figure 12. Jack pine - untreated; after 14-week rain test (accelerated weathering).

Figure 13. Jack pine - dipped green, Cunapsol; after 14-week rain test (accelerated weathering).

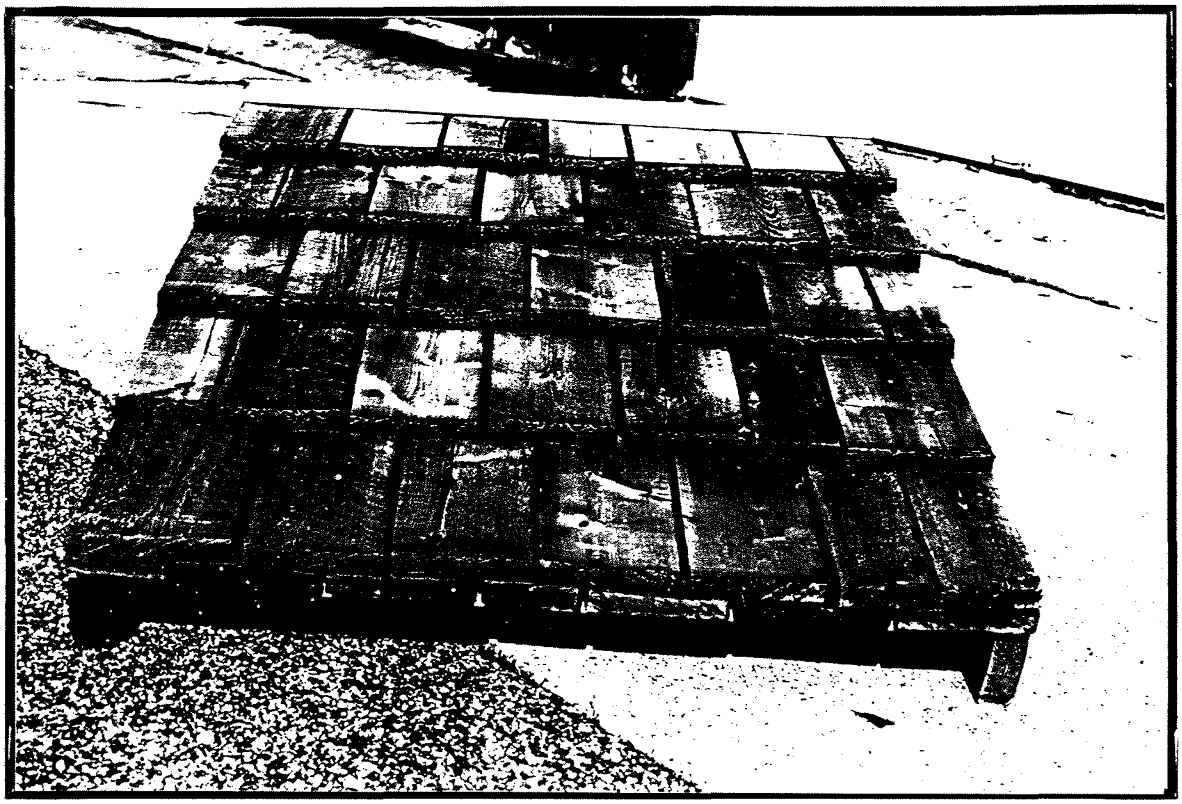

Figure 14. Jack pine - dipped dry, Cunapsol; after 14-week rain test (accelerated weathering).

Figure 15. Lodgepole pine - untreated; after 14-week rain test (accelerated weathering).

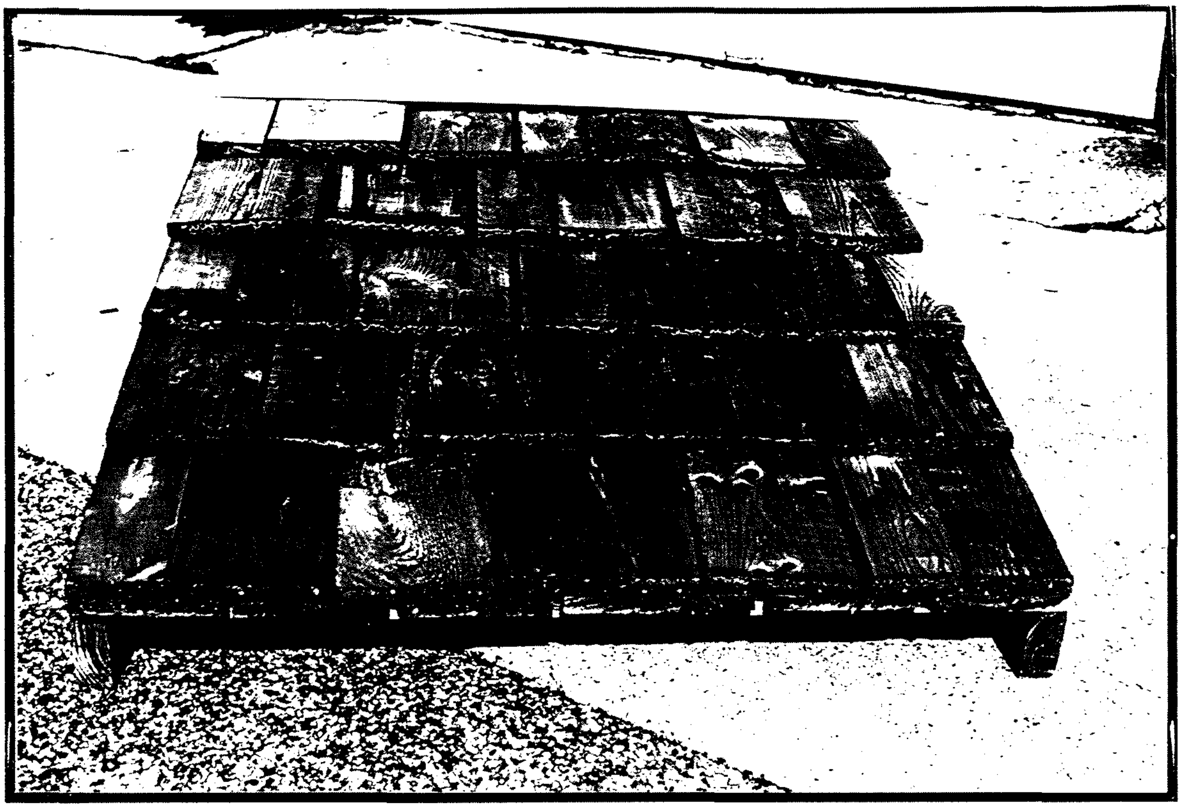

Figure 16. Lodgepole pine - dipped green, Cunapsol; after 14-week rain test (accelerated weathering).

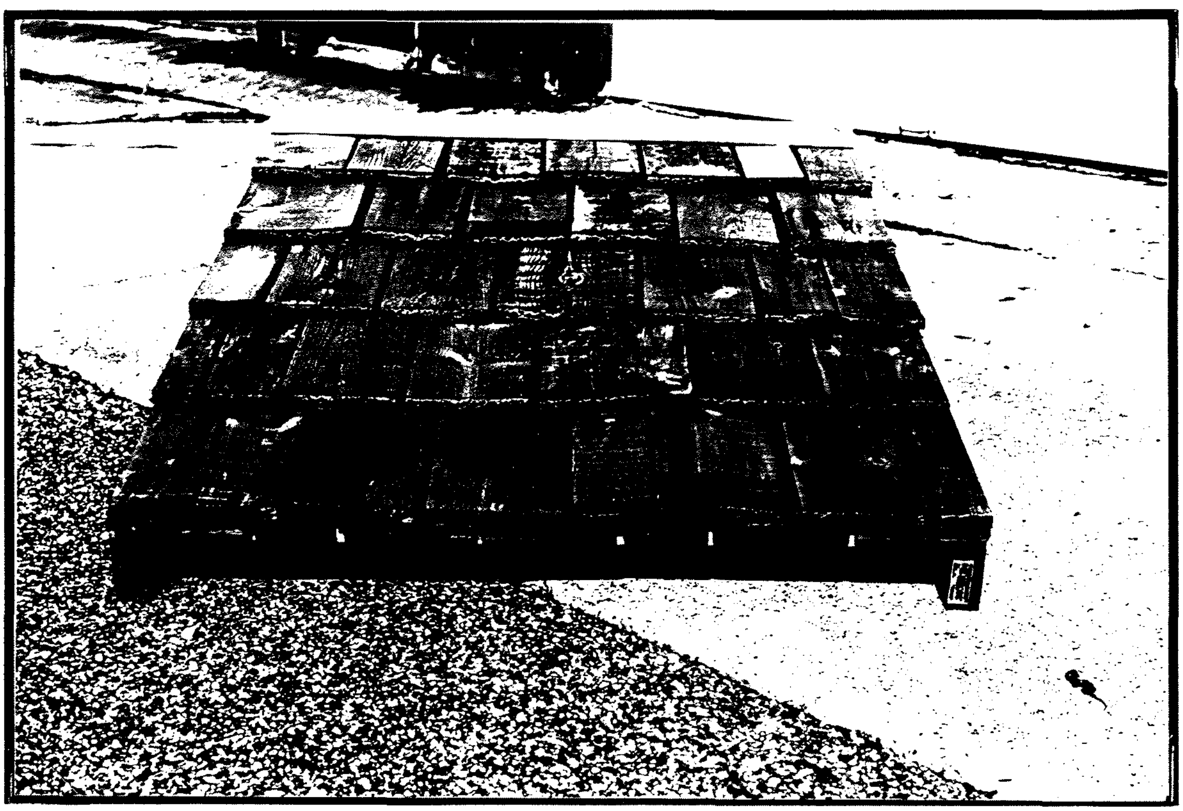

Figure 17. Lodgepole pine - dipped dry, Cunapsol; after 14-week rain test (accelerated weathering).

Figure 18. Lodgepole pine - dipped dry, Cunapsol; after 14-week rain test (accelerated weathering). Note major split in flat sawn portion of shake.

Figure 19. Aspen - untreated; after 14-week rain test (accelerated weathering).

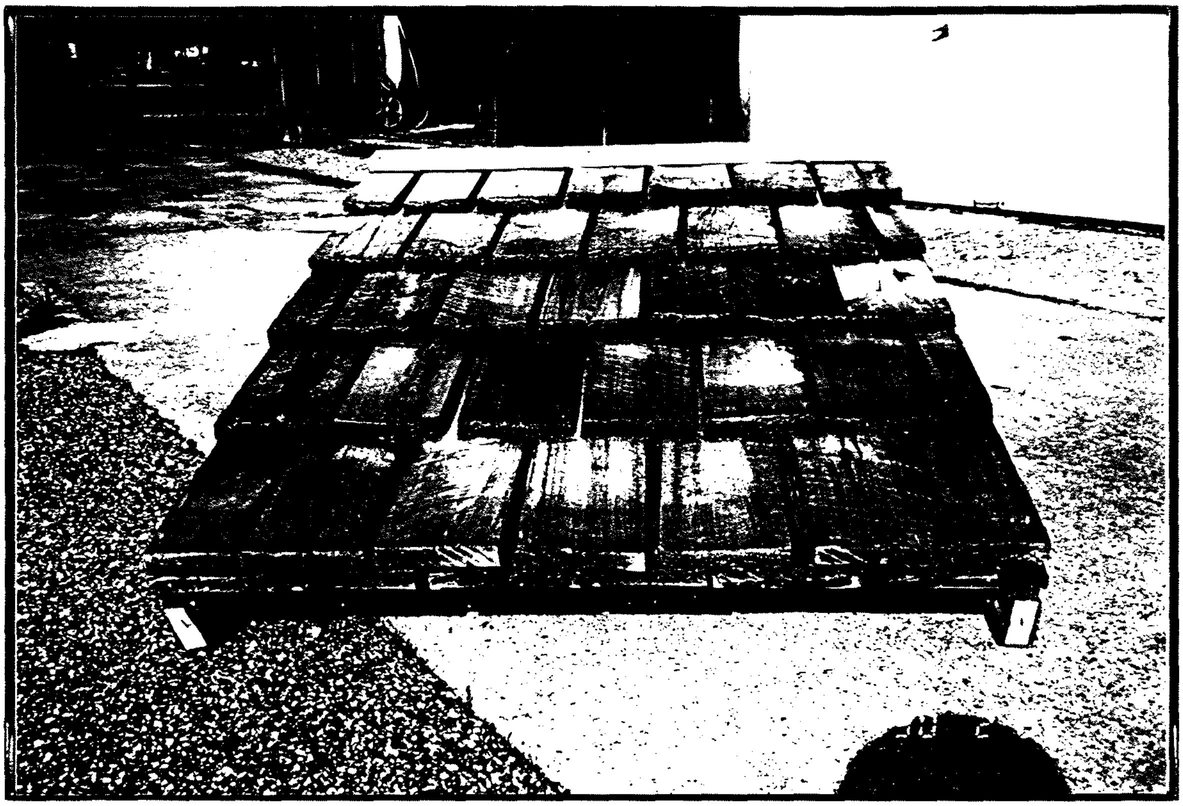

Figure 20. Aspen - dipped green, Cunapsol; after 14-week rain test (accelerated weathering).

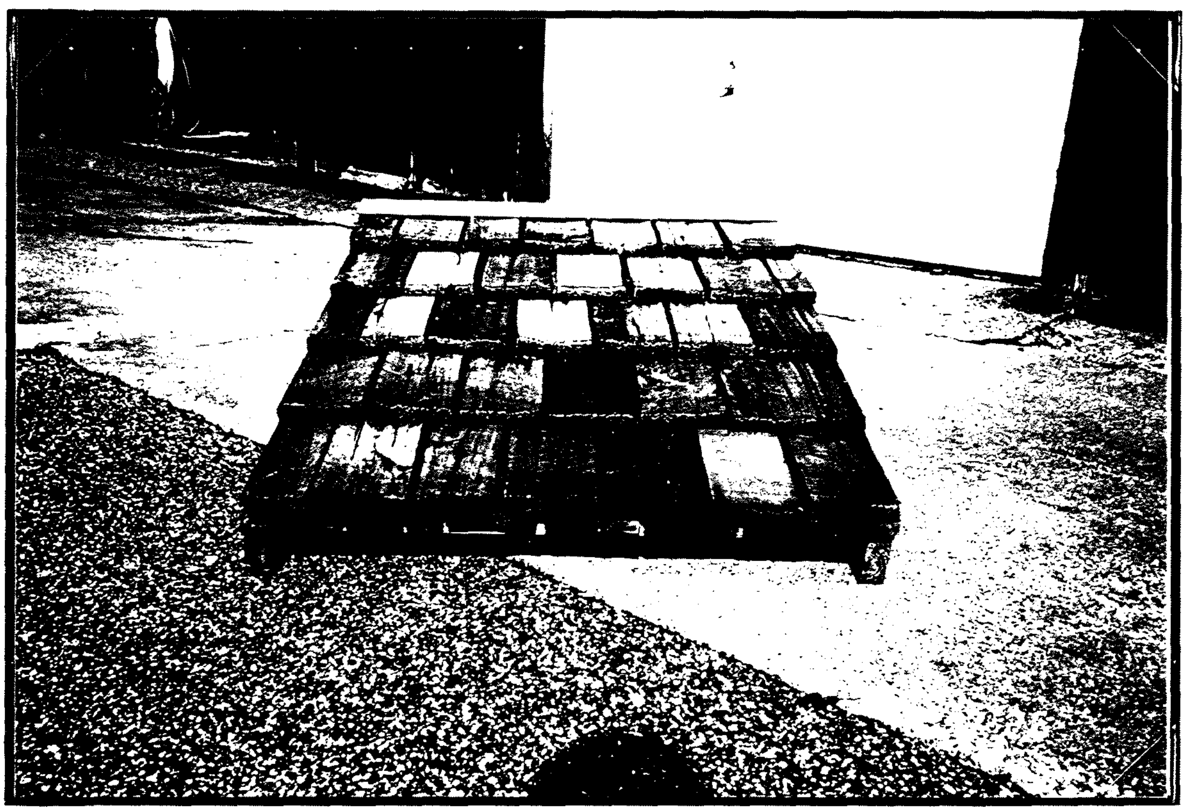

Figure 21. Aspen - dipped dry, Cunapsol; after 14-week rain test (accelerated weathering).

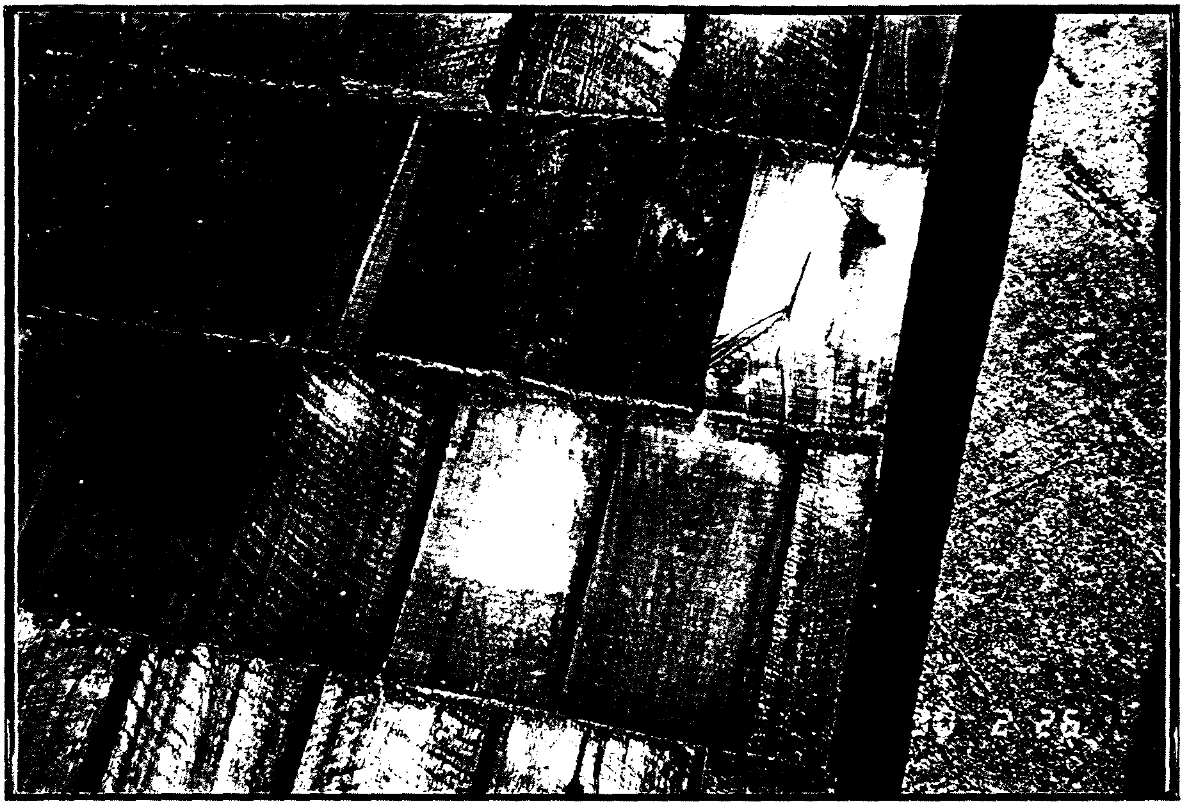

Figure 22. Aspen - dipped green, Cunapsol; after 14-week rain test (accelerated weathering). Note numerous minor and major splits forming in shakes.

4.2 Chemical Analysis (14-Week Rain Test)

4.2.1 Treating Solutions

The water-borne preservative selected for this project was Cunapsol, manufactured and distributed by Chapman Chemical Company in Memphis, Tennessee. Historical data on this product is extensive, and therefore too lengthy to include in this report. Suffice it to say that the Cunapsol product has demonstrated excellent mold, mildew and decay resistance in the field as well as resistance to insect attack. The Texas Forest Service has been recommending and using this product for almost 10 years with excellent results, particularly with wood roofing.

Recommendations were to dip the shakes in a 0.5 to 1.0% Cunapsol solution for 24 hours. Historical data shows this concentration to be quite effective in protecting Southern pine shakes exposed in East Texas. The Cunapsol arrived in a 5% concentrate form, requiring dilution with water at a 1:4 mixture to obtain a desired 1% concentration. This was done and samples of the treating solutions for both the dry and green dipped shakes were taken. To prevent the green discoloration of the shakes due to the prescence of copper napthenate, an acid orange dye was added to the treating solutions (0.2%) giving it a pleasing cedar-brown color. This coloration is not permanent and eventually will be leached out by rainfall within a year or two.

Samples for the chemical analysis of the treating solutions were collected at the conclusion of the dip treatments, as follows:

- 1% Cunapsol with 0.2% acid orange dye used to treat the "green" shakes. Analyzed at 0.61% copper. Target concentration was 1.0% copper.
- 1% Cunapsol with 0.2% acid orange dye used to treat dry shakes. Analyzed at 0.58% copper. Target concentration was 1.0% copper.

No explanation has been found as to why the Cunapsol solutions were not up to the desired concentrations. All mixing of the Cunapsol and water was performed according to laboratory standards by lab personnel. This is being investigated further.

4.2.2 Cunapsol Penetration

In addition to inspecting the treated shakes for retentions of Cunapsol, test shakes were also inspected for maximum penetration.

Table 3 gives the results of "pan indicator tests" where the penetration of the Cunapsol into the face and butt of the shakes was measured directly.

TABLE 3. ANALYSIS FOR CUNAPSOL PENETRATION FOLLOWING 14-WEEK RAIN TEST

Species	Dipped Green vs. Dipped Dry	Average Penetration at Butt Zone (inches)	Average Lateral into Shake Face (inches)
Aspen	Green	0.6250	0.1406
Aspen	Dry	0.3281	0.1094
Jack Pine	Green	0.6250	0.1406
Jack Pine	Dry	0.2031	0.0469
Lodgepole Pine	Green	0.3125	0.2500
Lodgepole Pine	Dry	0.3438	0.0781

NOTE:
Penetration of Cunapsol measured directly through the use of a pan indicator solution.

TABLE 4. RESULTS OF CHEMICAL ANALYSIS FOR RETENTIONS OF CUNAPSOL WEATHERED AND UNWEATHERED SHAKES[(3)]

Species	Dipped Green/ Dipped Dry	Weathered/ Unweathered	Species Density lbs/cu.ft[(1)]	Percent Copper[(2)]	lbs./cu.ft. Copper
Aspen	Green	U	30.37	0.23	0.0699
Aspen	Green	W	30.81	0.12	0.0370
Aspen	Dry	U	27.93	0.45	0.1257
Aspen	Dry	W	30.98	0.22	0.0682
Jack Pine	Green	U	33.05	0.49	0.1619
Jack Pine	Green	W	28.46	0.32	0.0911
Jack Pine	Dry	U	32.72	0.27	0.0883
Jack Pine	Dry	W	28.78	0.21	0.0604
Lodgepole Pine	Green	U	30.96	0.36	0.1115
Lodgepole Pine	Green	W	27.25	0.45	0.1226
Lodgepole Pine	Dry	U	31.49	0.24	0.0756
Lodgepole Pine	Dry	W	28.85	0.27	0.0779

(1) Density of the species was obtained by measuring oven-dried samples (dimension) and taking their weights

(2) The percent copper content was supplied by Barrow Agee Labs, Memphis, Tennessee

(3) Samples taken for chemical analysis were from the bottom one inch zone of the butt of the shakes. Samples were taken before and after weathering.

4.2.3 Cunapsol Retentions

Table 4 lists the retentions of Cunapsol achieved through 24-hour dip treatment.

The leaching effect of the 14-week rain test is equivalent to approximately 800 inches of rainfall. Results from field studies in Texas with dip treated southern pine shakes (in Cunapsol) show no mold, mildew or decay after 5 years. These results are impressive considering the decay potential in East Texas. Untreated southern pine shakes will normally last only 2 to 3 years before being destroyed by decay fungi.

In Canada, and particularly in the Canadian prairies, the decay potential is much less severe because of our colder climate and reduced rainfall. Results from the 14-week rain test indicate that there is sufficient Cunapsol in the shakes following weathering to provide good protection, especially against above ground fungi. There is not enough Cunapsol present, however, to stop or inhibit termite attack, which is of little consequence in at least the Prairie marketplace.

The chemical analysis data indicates that all three species were reasonably treated with the Cunapsol solution, both with wet wood and dry wood. Penetration into the butt zone was quite adequate with the Cunapsol migrating as much as a half inch or more. This is important since most decay in shakes originates at the butt, 1 inch at the overlap region. Lateral penetration into the shakes was considerably less, but fairly typical of most dip treatments.

Overall retentions of Cunapsol would have been somewhat higher if the treating solutions had been stronger. No explanation has yet been determined why the solutions were not closer to the desired 1% concentration. Further investigations are in progress to determine the problem. One mitigating consideration is that the higher concentration solutions tend to concentrate on the surface of the shakes and do not penetrate, eventually leaching away by rainfall at an accelerated rate. This is why higher than 1% Cunapsol solutions are not recommended for dip treating shakes.

5.0 RESULTS - FIELD EXPOSURE

In order to correlate accelerated weathering data with outdoor exposure data, duplicate test decks of both treated and untreated shakes were placed outside at the Hudson research site near Lufkin in August, 1989. Because the 14-week rain test does not involve exposure to ultraviolet light (a component of sunlight), or mold, mildew or other decay organisms, this data will be essential in evaluating the performance of these species as roof coverings.

TABLE 5. 60-Month Outdoor Exposure Field Test, Hudson Research Station (1)

Panel No.	Description
1	Jack pine, untreated
2	Aspen, untreated
3	Lodgepole pine, untreated
4	Lodgepole pine dipped green in Cunapsol
5	Aspen dipped green in Cunapsol
6	Jack pine dipped green in Cunapsol
7	Aspen dipped dry in Cunapsol
8	Lodgepole pine dipped dry in Cunapsol
9	Jack pine dipped dry in Cunapsol

(1) Test panels installed on a 5:12 pitch facing true south in full sun. Panels installed and photographed 7/28/89.

Other wood species are already on exposure at the site in both treated and untreated form. Some of the important species are:

- Western red cedar
- Western hemlock
- Southern pine
- Yellow poplar

- ° Red oak/White oak
- ° Blackgum/Sweetgum

These species are being evaluated over long-term exposure for decay resistance and stability. Additional species are to be added in future studies.

Figures 23 to 47 illustrate the field exposure trials at Hudson, Texas. These photographs were taken February 26, 1990, approximately 7 months after the shakes were installed. Clearly, this relatively short period of outdoor exposure was more severe than the 14-week rain test. Furthermore, the Texas climate is much harsher than the western Canadian climate (much more heat, rainfall, humidity, decay, insects, fungi, etc.). Outdoor exposure in east Texas is a real "acid test" - if shakes can hold up under these conditions, then they should perform satisfactorily anywhere. It should be remembered that these test decks are constructed from ungraded shakes which are known to contain a variety of defects. The field exposure trials should help to determine the relative significance of different defects, and will help determine quality standards which should be followed.

Figures 48 and 49 illustrate two of the test roofs installed at Lac La Biche, Alberta in August of 1989. These roofs are also constructed from ungraded shakes which are known to contain a variety of defects. They are in excellent condition, which is not surprising considering they have been exposed to fall and winter seasons only. These roofs will be monitored for several years and will serve as an Alberta calibration for the Texas field trials.

Figure 23. Jack pine - untreated. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

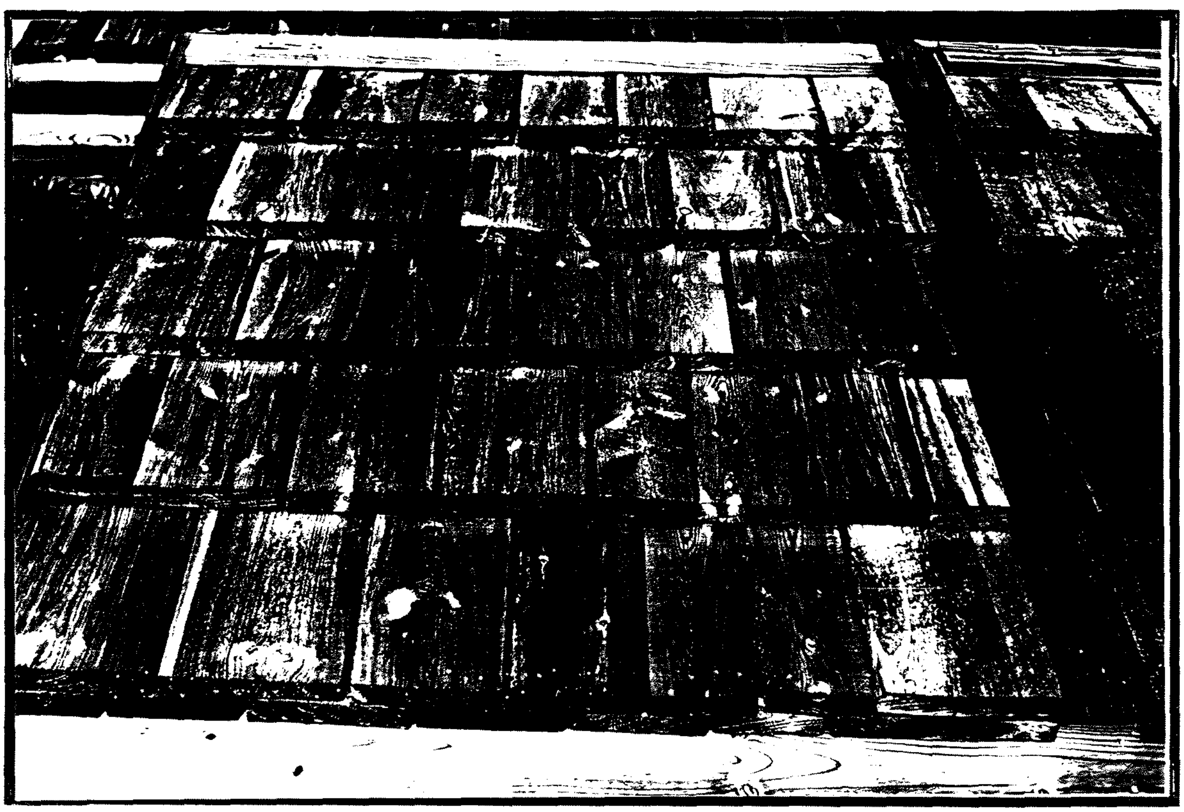

Figure 24. Jack pine - untreated. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

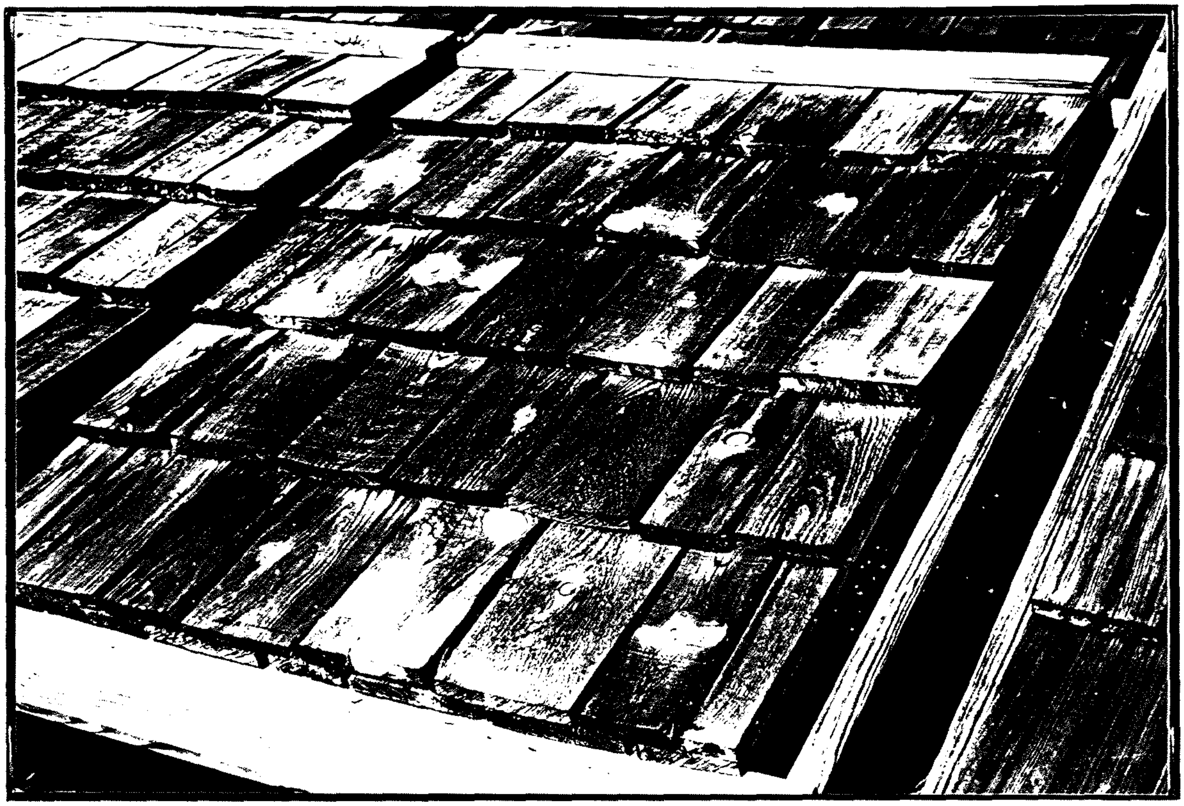

Figure 25. Lodgepole pine - untreated. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

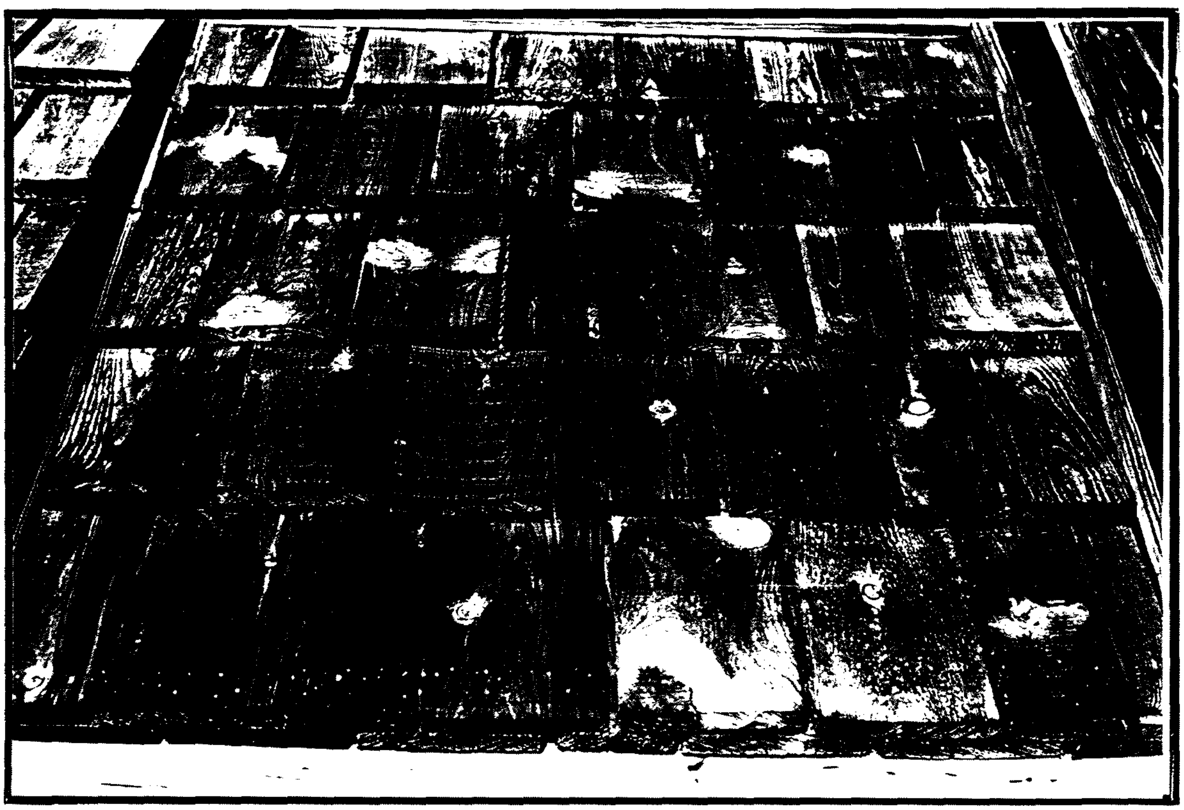

Figure 26. Lodgepole pine - untreated. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

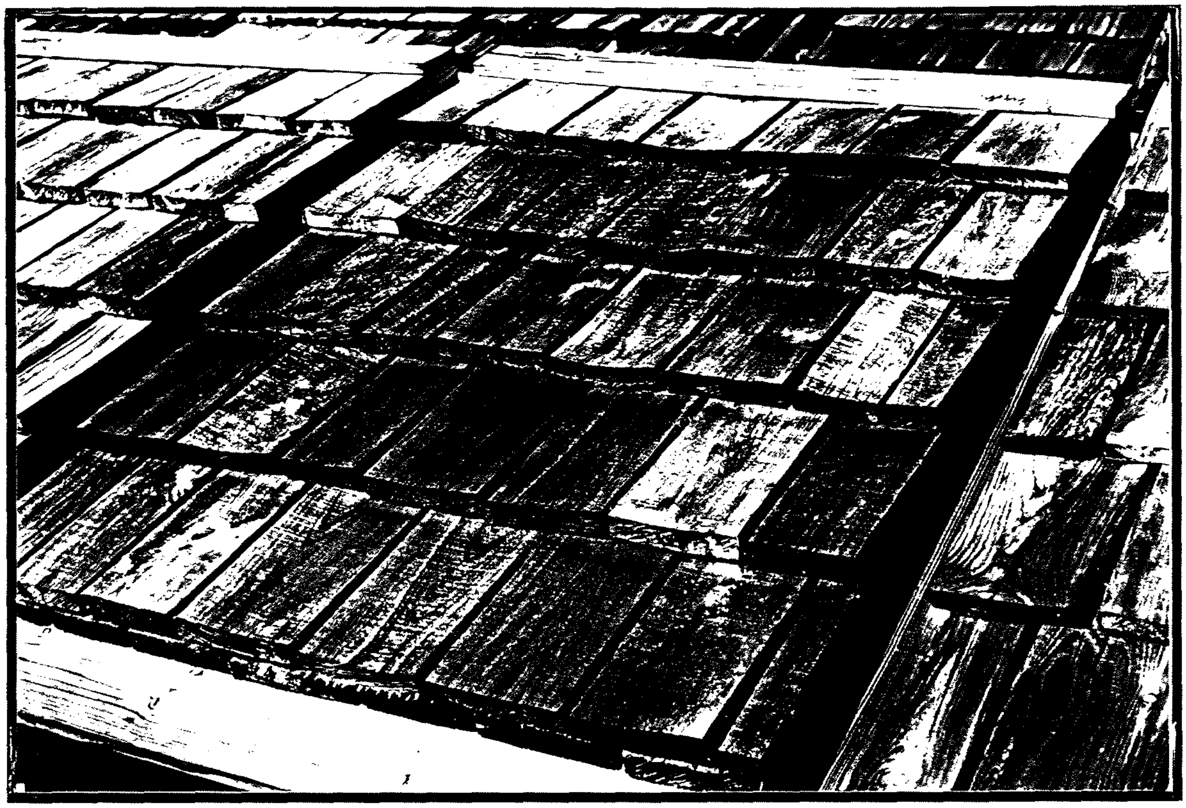

Figure 27. Aspen - untreated. Field exposure test, Hudson, Texas.
Installed 7/29/89. Photographed and inspected 2/26/90.

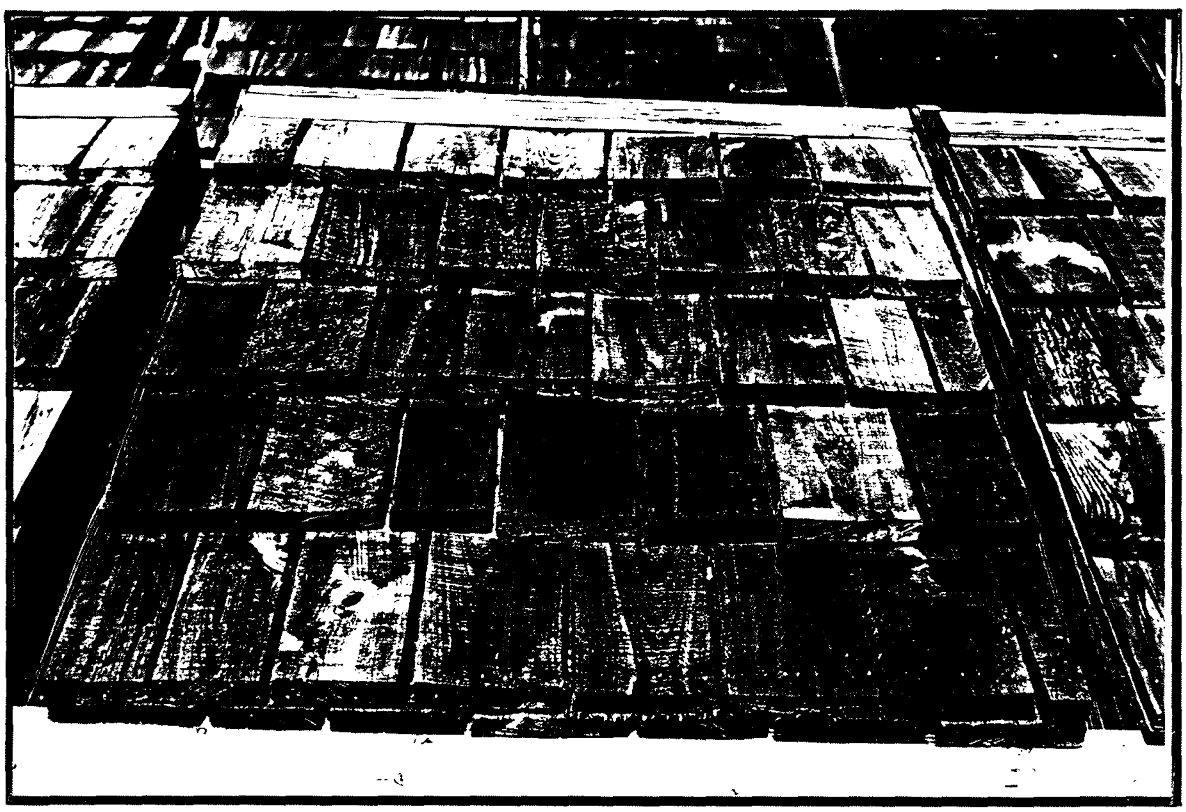

Figure 28. Aspen - untreated. Field exposure test, Hudson, Texas.
Installed 7/29/89. Photographed and inspected 2/26/90.

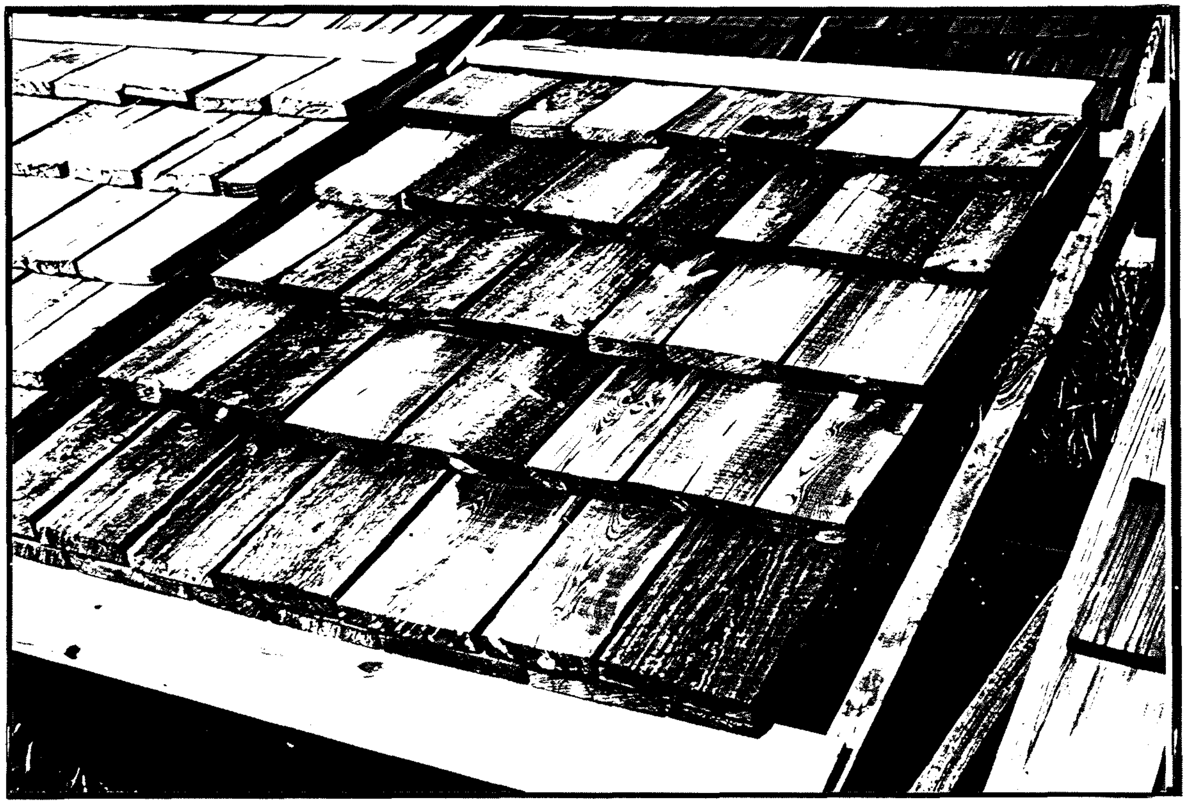

Figure 29. Jack pine - dipped green, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

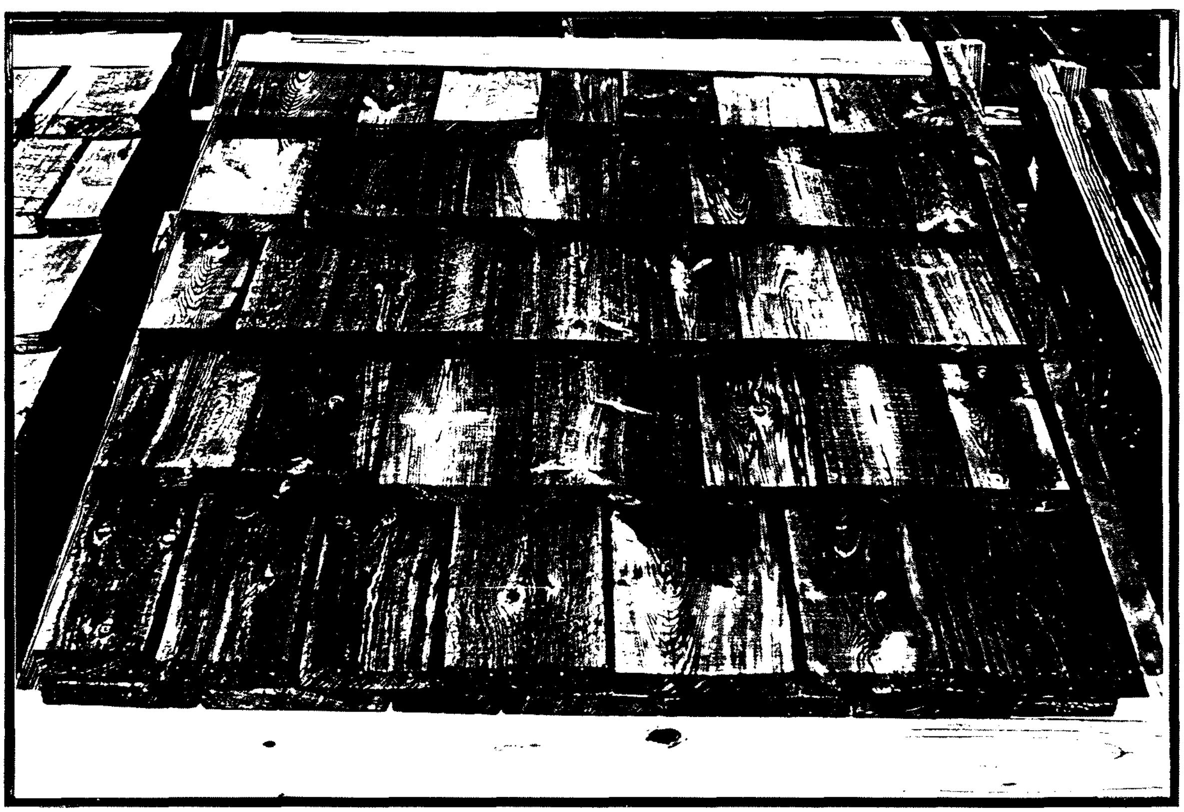

Figure 30. Jack pine - dipped green, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

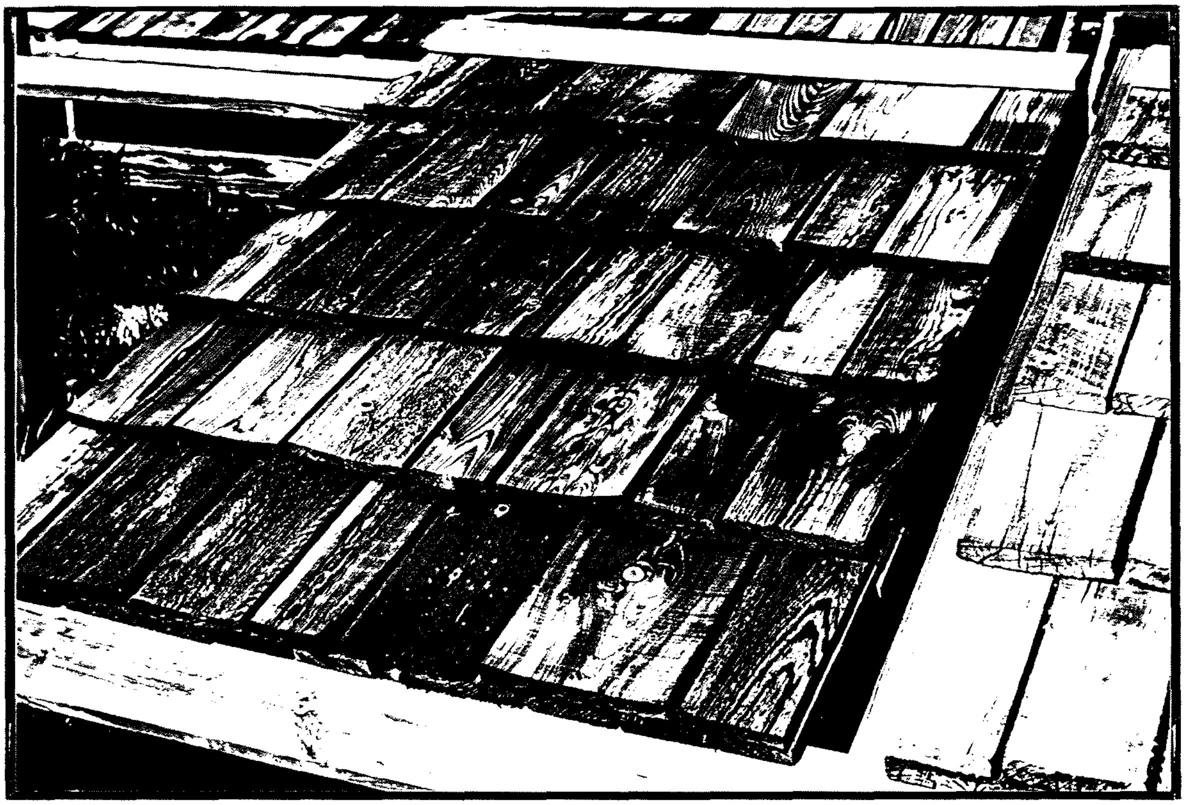

Figure 31. Lodgepole pine - dipped green, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

Figure 32. Lodgepole pine - dipped green, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

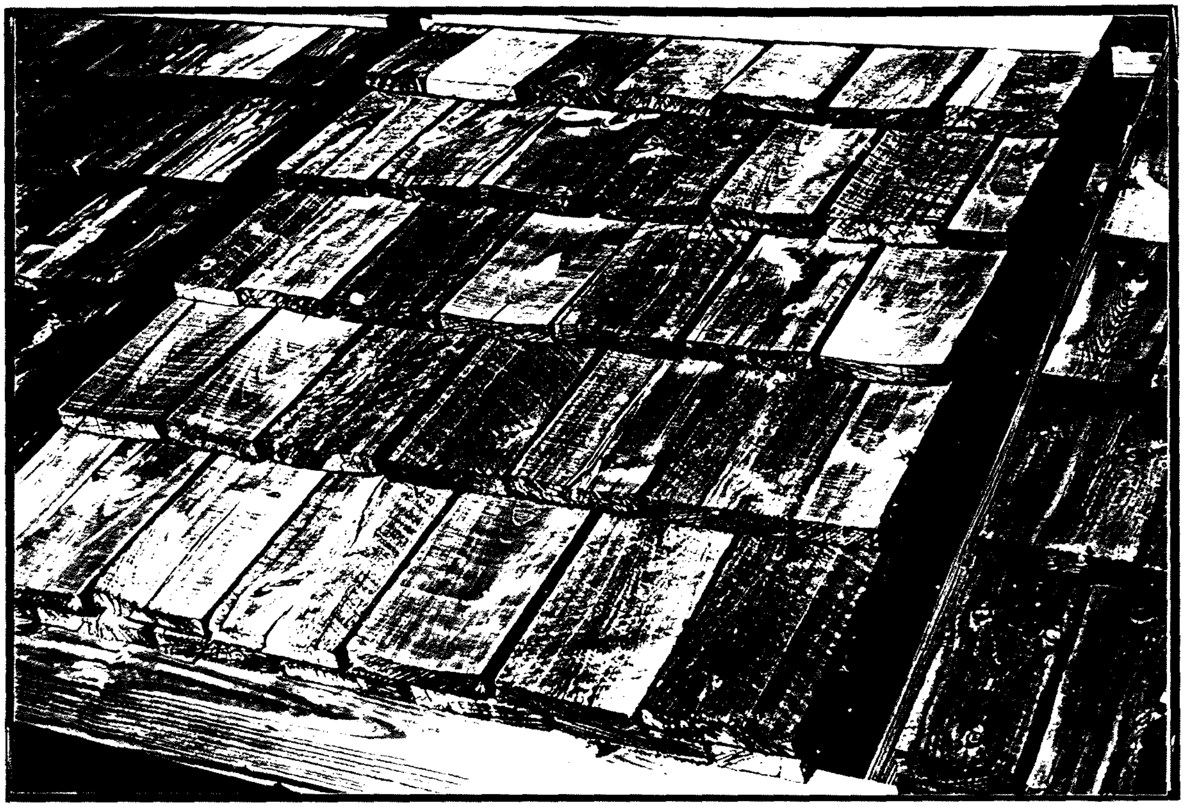

Figure 33. Aspen - dipped green, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

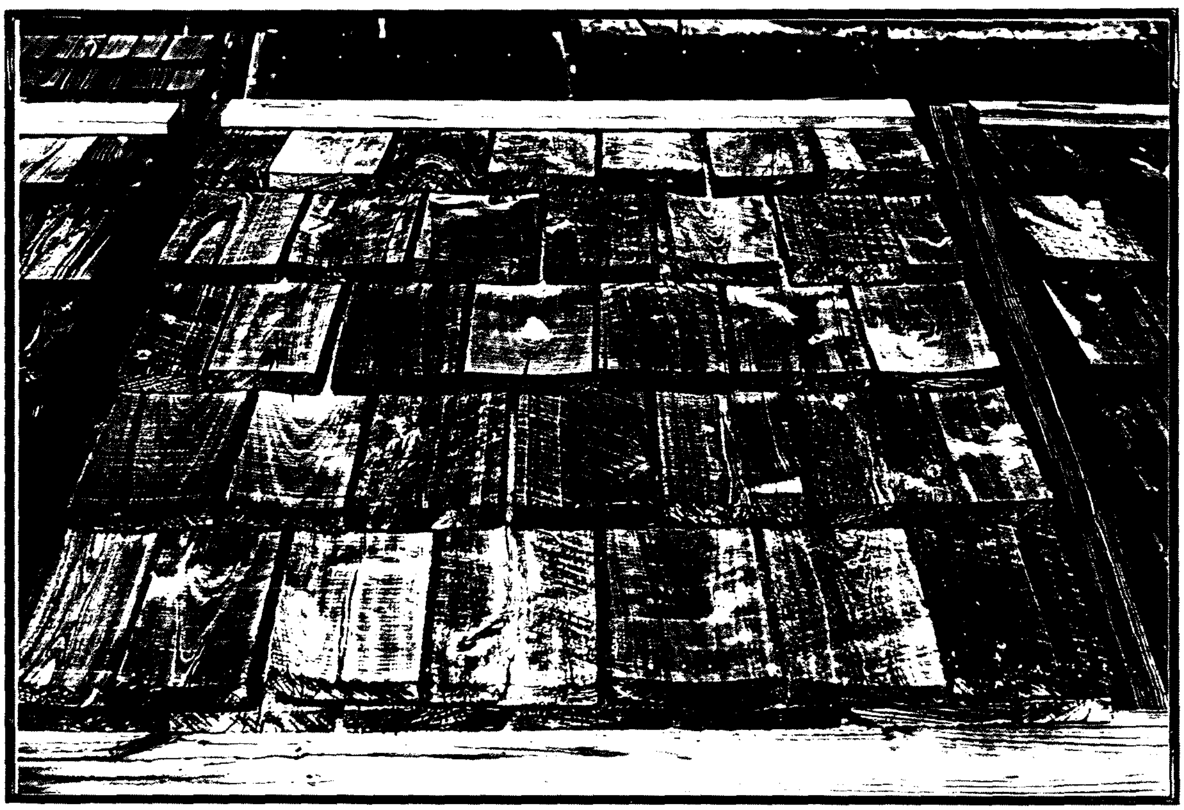

Figure 34. Aspen - dipped green, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

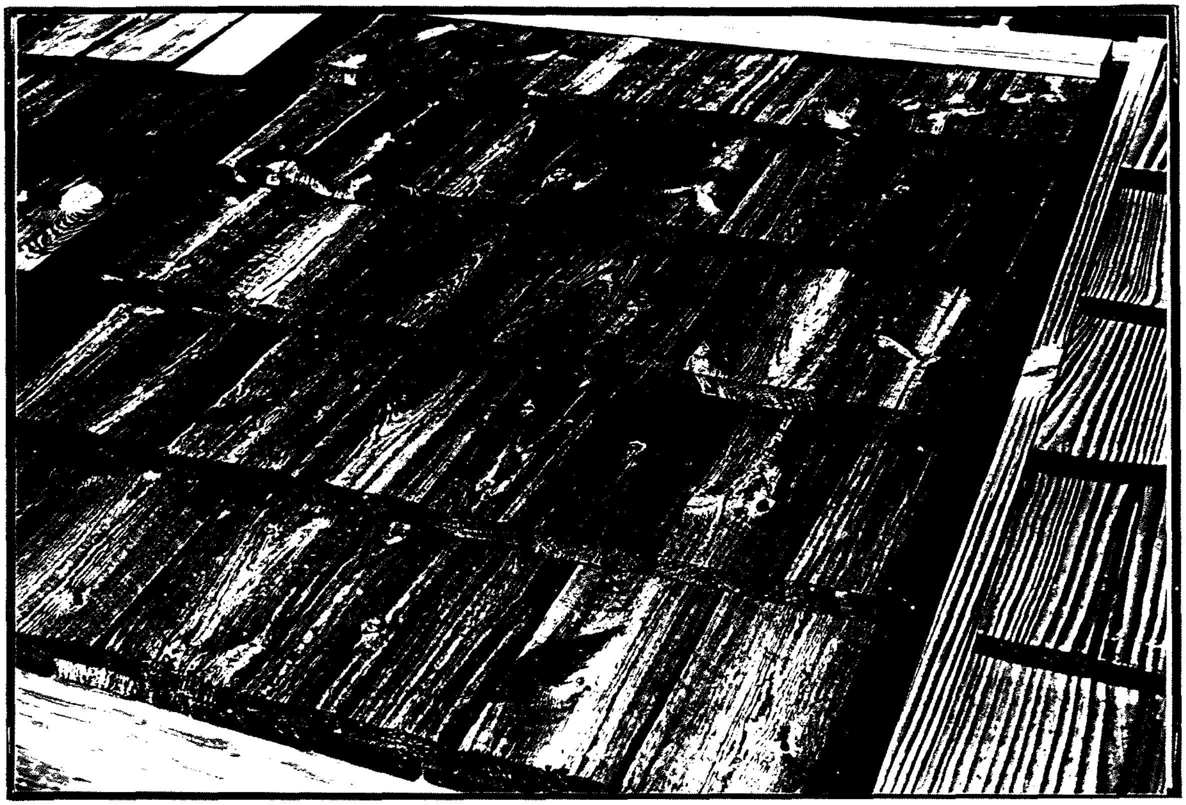

Figure 35. Jack pine - dipped dry, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

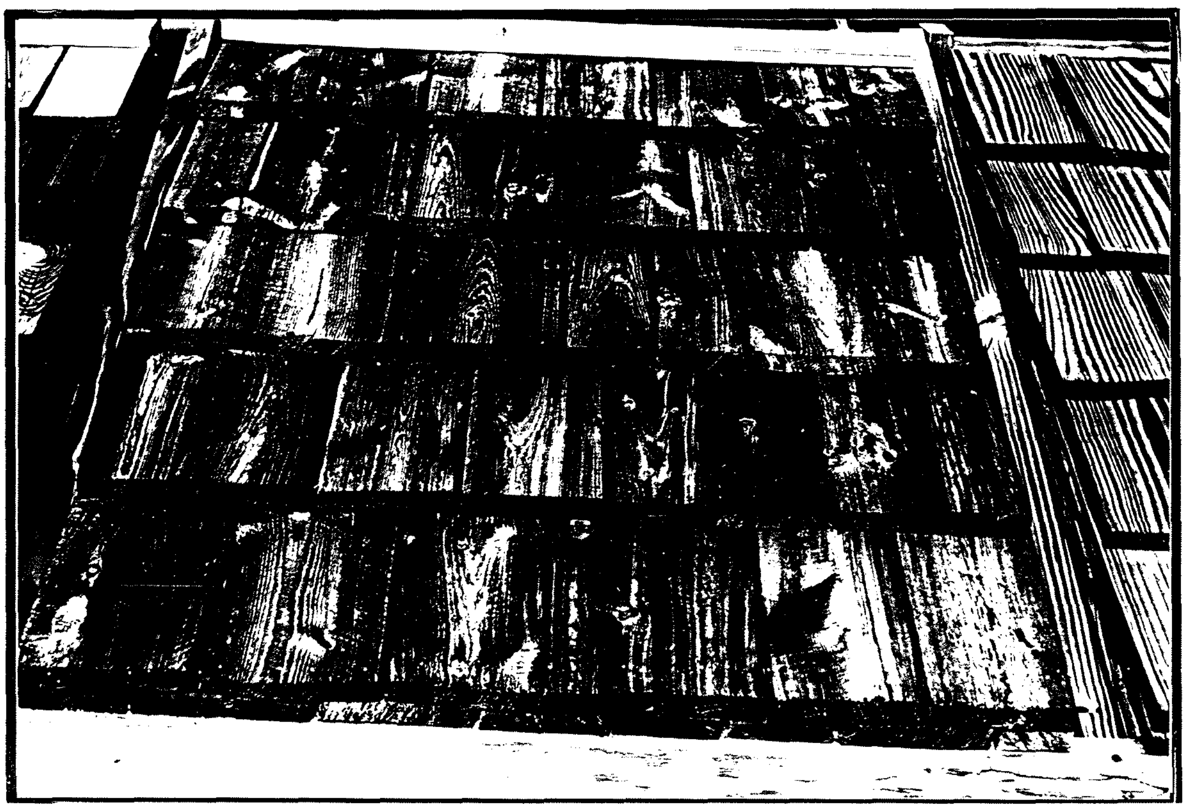

Figure 36. Jack pine - dipped dry, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

Figure 37. Lodgepole pine - dipped dry, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

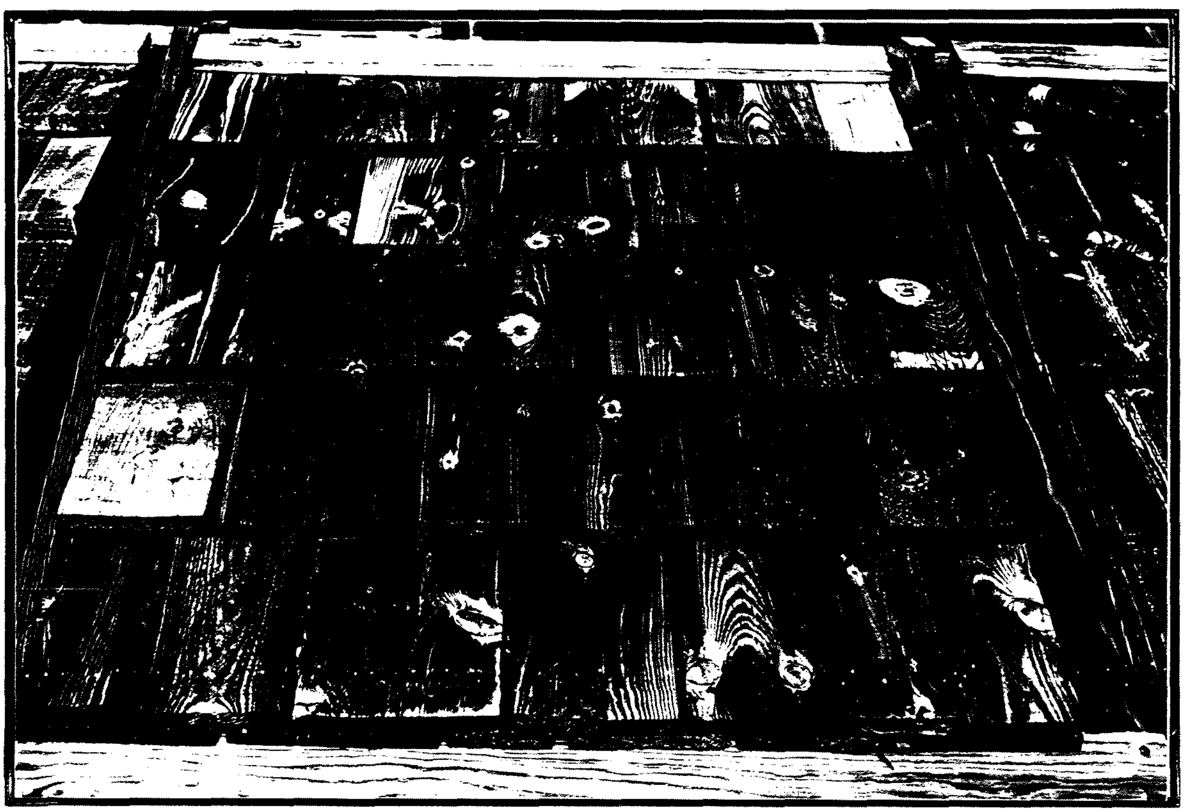

Figure 38. Lodgepole pine - dipped dry, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

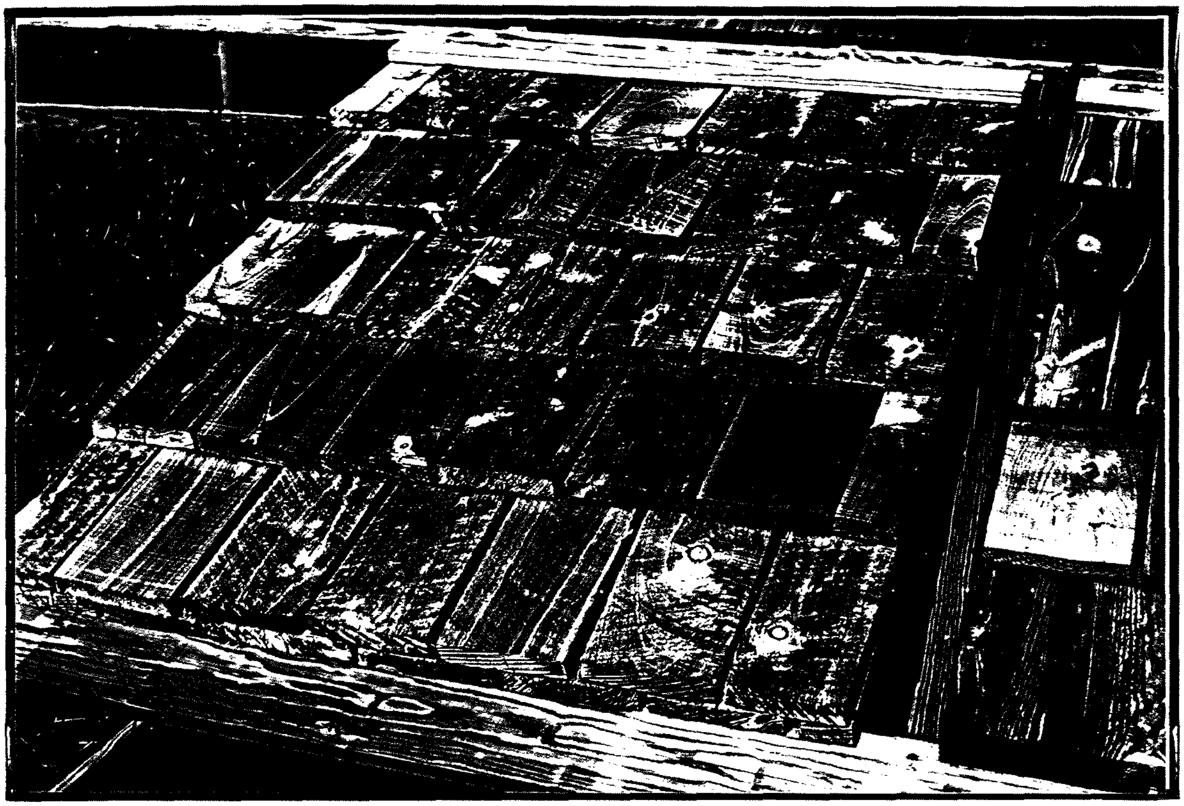

Figure 39. Aspen - dipped dry, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

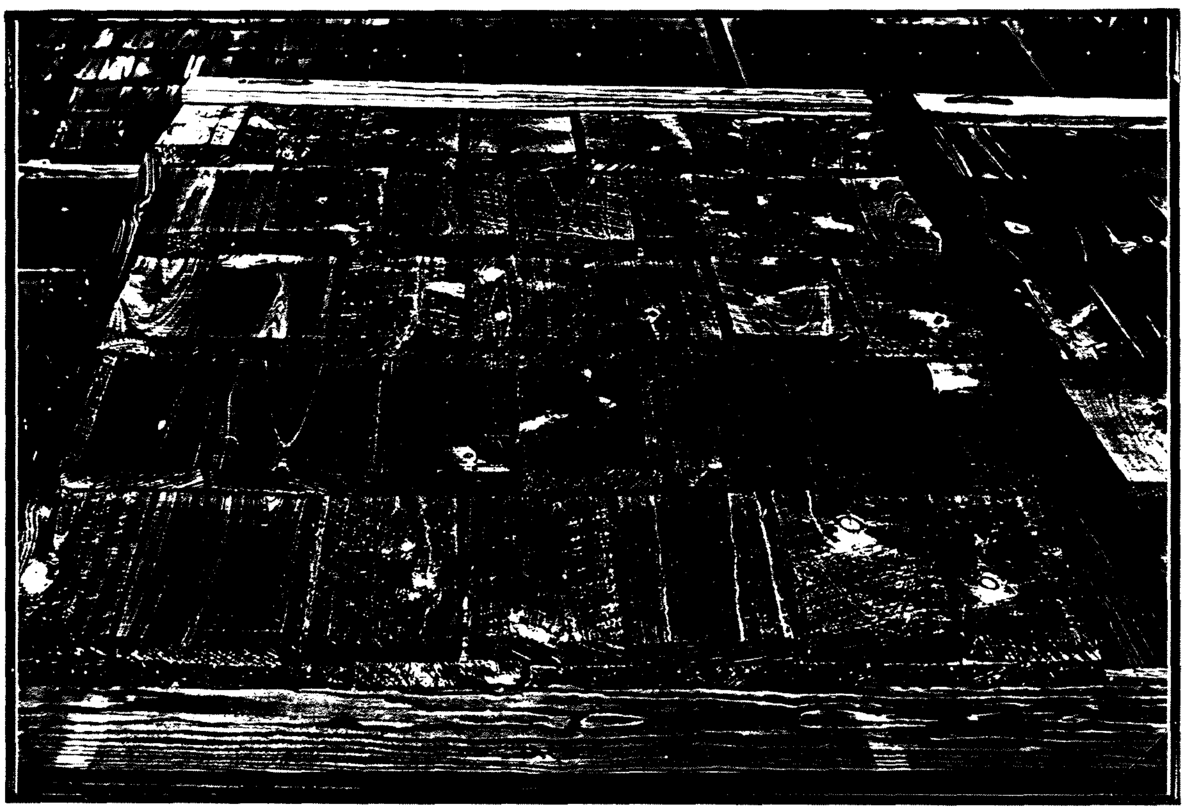

Figure 40. Aspen - dipped dry, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

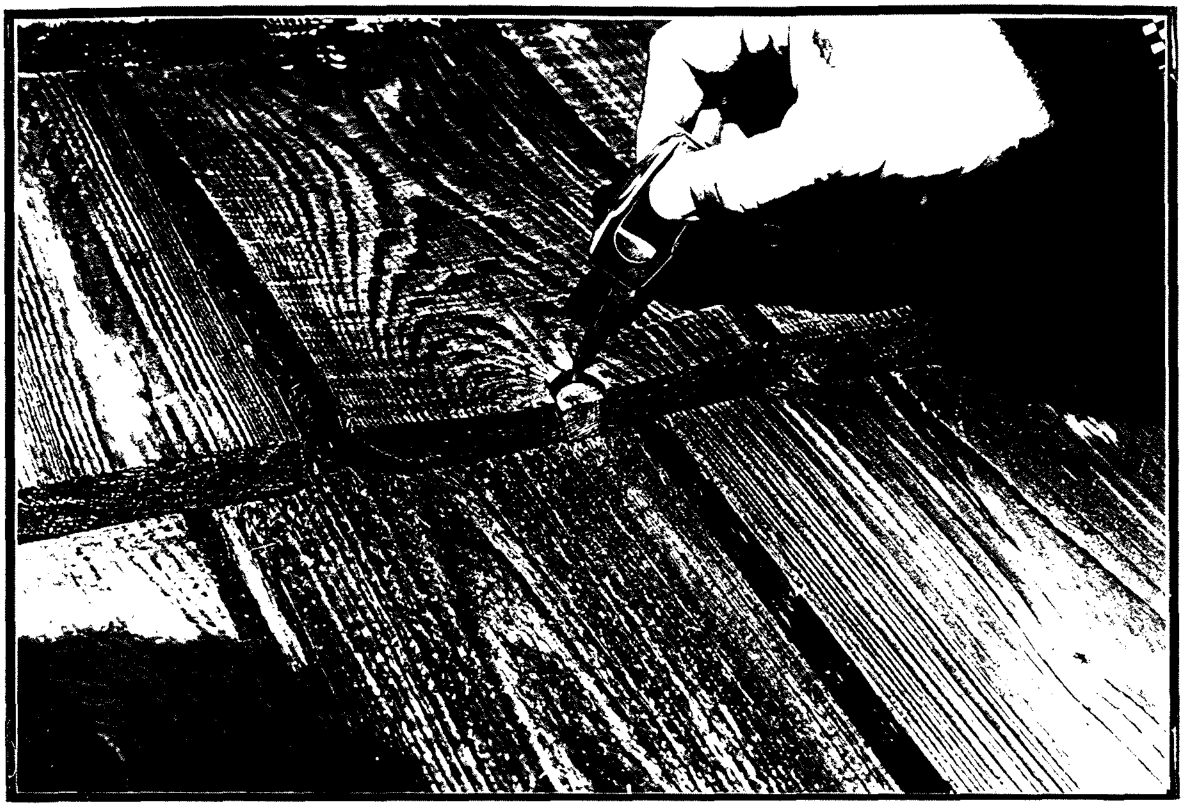

Figure 41. Black ring knot (loose). Lodgepole pine - dipped dry, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

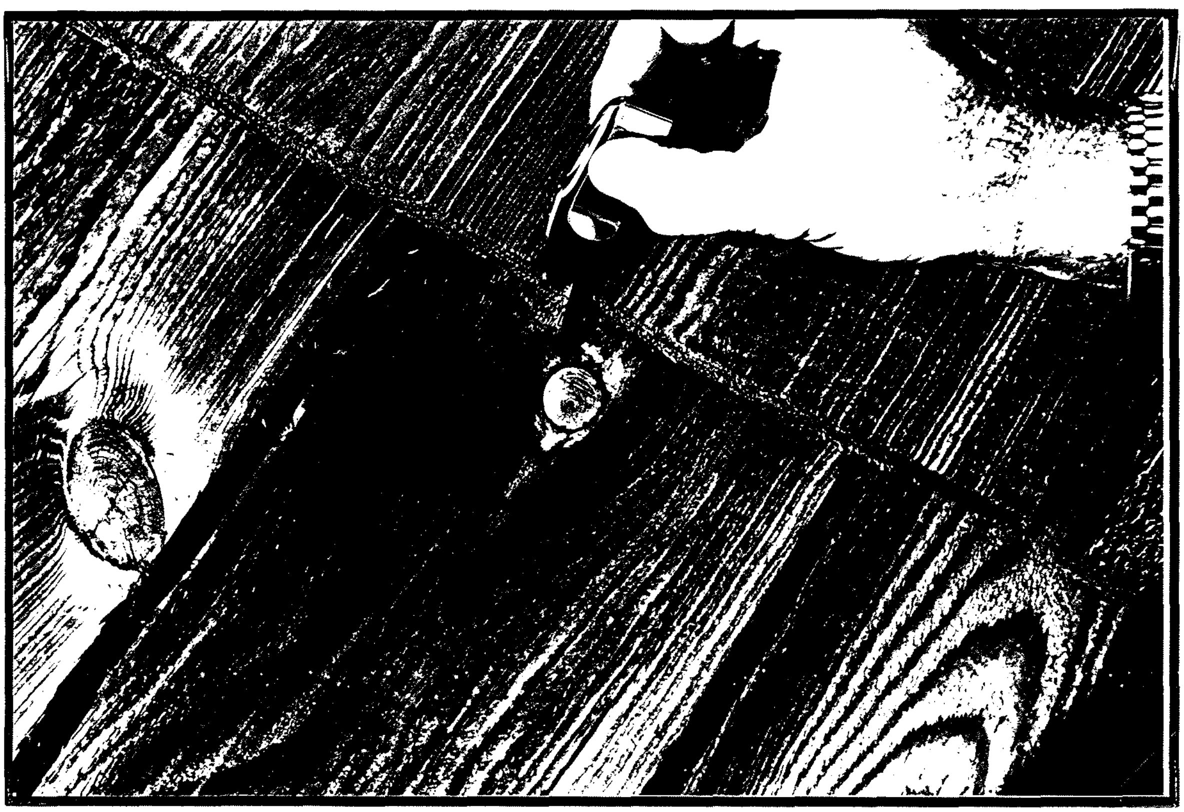

Figure 42. Black ring knot (loose). Lodgepole pine - dipped dry, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

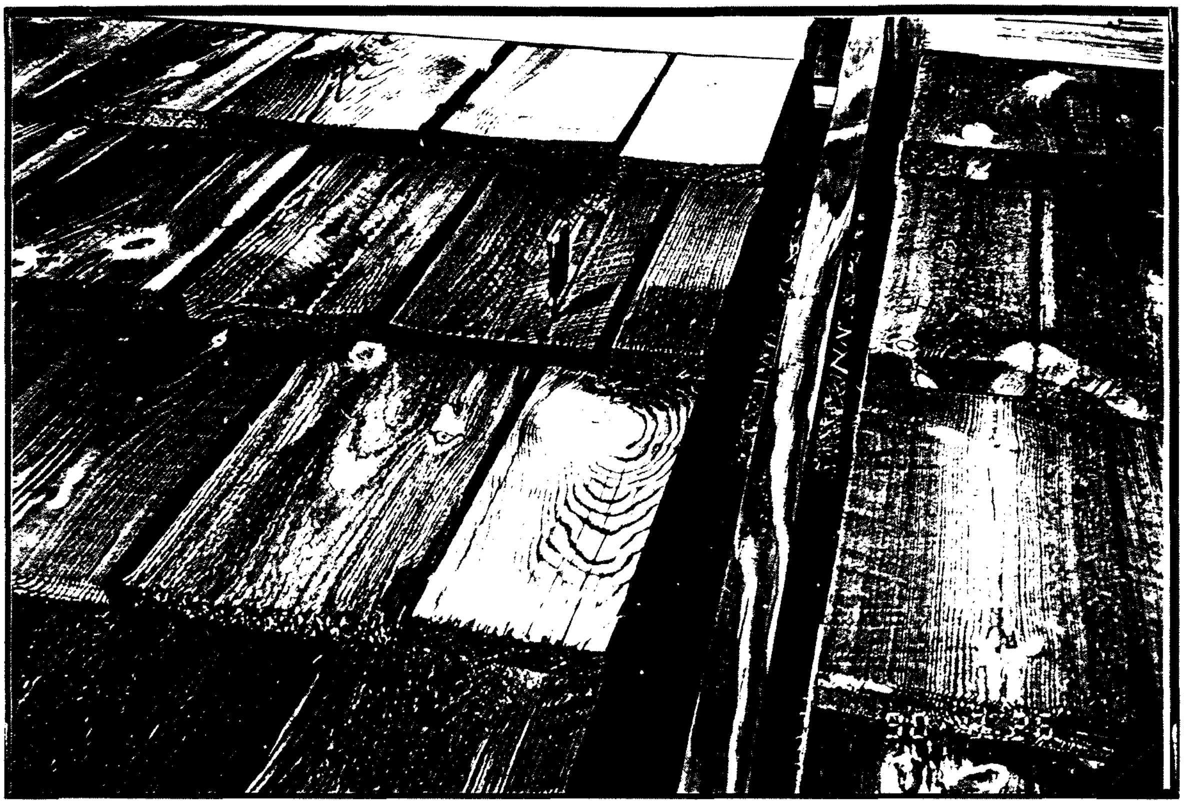

Figure 43. Major split, flat sawn. Lodgepole pine - dipped dry, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

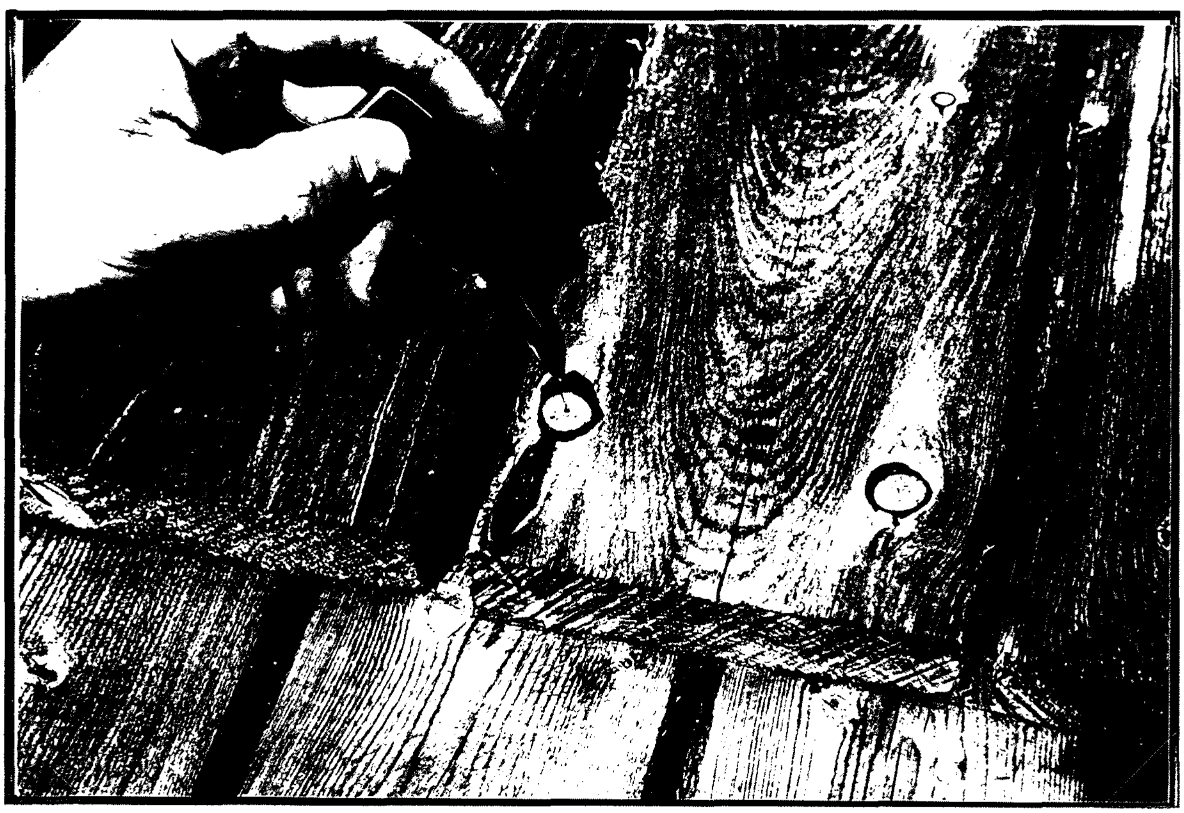

Figure 44. Black ring knot (loose). Jack pine - untreated. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

Figure 45. Minor split, flat sawn; Jack pine - untreated; Field exposure test, Hudson, Texas; Installed 7/29/89; Photographed and inspected 2/26/90

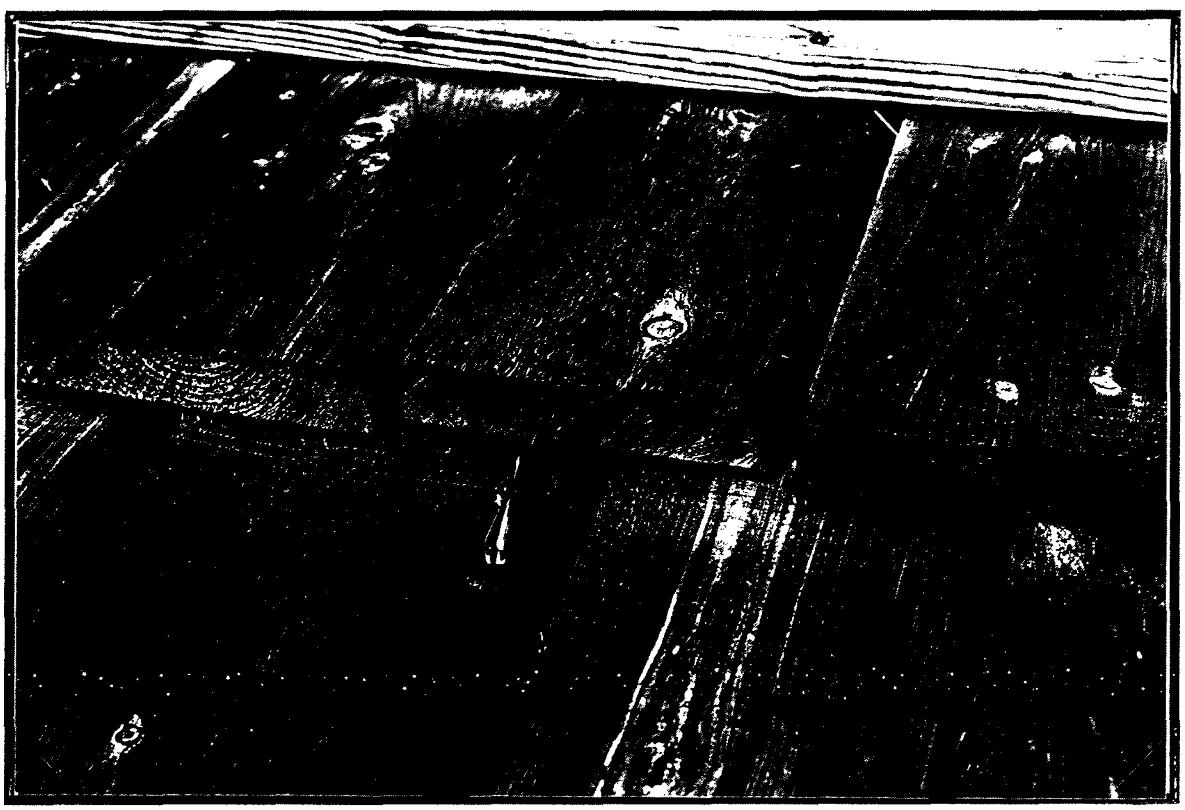

Figure 46. Minor split, flat sawn. Jack pine - untreated. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

Figure 47. Loose pith, flat sawn. Jack pine - dipped green, Cunapsol. Field exposure test, Hudson, Texas. Installed 7/29/89. Photographed and inspected 2/26/90.

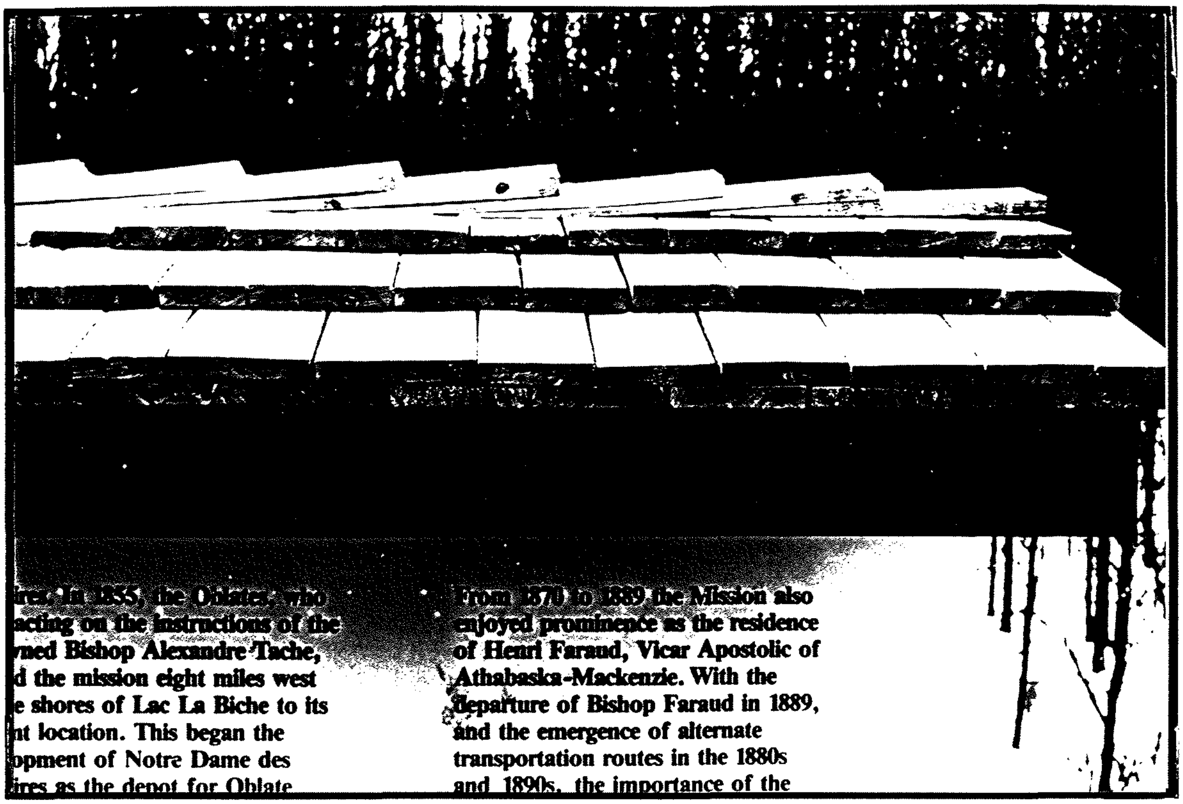

Figure 48. Jack pine - untreated. Field exposure test, Lac La Biche, Alberta. Installed 8/15/89. Photographed and inspected 3/11/90.

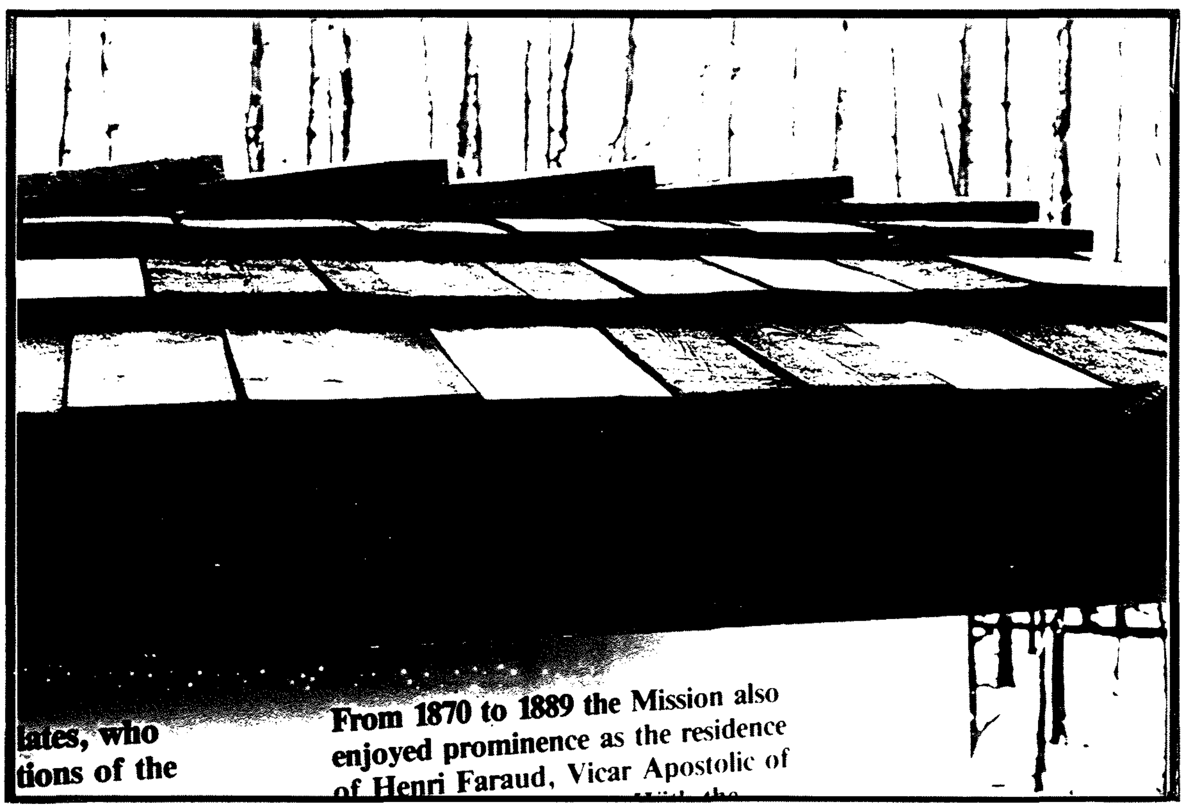

Figure 49. Jack pine - dipped green, Cunapsol. Field exposure test, Lac La Biche, Alberta. Installed 8/15/89. Photographed and inspected 3/11/90.

6.0 CONCLUSIONS

6.1 Accelerated Weathering

The results of the accelerated weathering trials indicate that all three candidate species (jack pine, aspen, and lodgepole pine) are sufficiently stable to allow their use as roofing shakes. While exhibiting greater numbers of defects in most categories than cedar, the three candidate species considered by this project came through the accelerated weathering process in relatively good shape. The jack pine shakes performed the best in the 14-week rain test. This result, however, might be partially attributable to their greater thickness compared to the lodgepole pine shakes. Even on an equal thickness basis, it is our opinion that jack pine will outperform lodgepole pine as a roofing shake.

6.2 Preservative Treatment - Cunapsol

The results of the accelerated weathering trials and the laboratory analysis of chemical penetration and retention indicate that a simple dip treatment with Cunapsol can be an effective and inexpensive method of protecting roofing shakes against decay. Even after the 14-week rain test (with a leaching effect equivalent to about 800 inches of rainfall), enough Cunapsol was retained in the shakes to provide good protection.

If marketed in extremely high decay zones, or regions where termites are a significant risk, Alberta shakes would have to be pressure treated with CCA.

There appears to be a detrimental side effect resulting from treating aspen shakes with Cunapsol. The accelerated weathering tests indicated this effect to a limited degree. The field exposure trials, however, reveal a dramatic phenomenon. Aspen shakes treated with Cunapsol, whether dipped green or dry, develop cracks and splits to a much greater degree than untreated aspen shakes. This effect was not noticeable in either the jack pine or the lodgepole pine. This is being investigated further.

6.3 Field Exposure

The field exposure trials in Texas and Alberta are only a few months old. However, even after this short time frame, several conclusions can be drawn:

- The Cunapsol treated aspen shakes are not performing well. Based on what we've seen to date, we do not recommend use of Cunapsol treated aspen as a roofing shake.

- The jack pine shakes are performing the best, followed by lodgepole pine, and then aspen.

- Jack pine and lodgepole pine should perform very well as roofing shakes provided that quality is maintained and defects are reduced.

- The quality of shake used in the testing (both accelerated weathering and field exposure) for this study is not adequate for a premium roofing shake. The main defects encountered in this study are:
  - flat sawn shakes
  - black ring, and otherwise loose, knots
  - pith portions.

6.4 General Conclusions

In general, we conclude that Alberta pine, and especially jack pine, will perform satisfactorily as a roofing shake, provided that quality is maintained and defects are minimized.

7.0 RECOMMENDATIONS

Our recommendations are summarized into point form, and cover technical aspects such as shake configuration, as well as strategic aspects for prospective manufacturers.

7.1 Technical Recommendations

1. For the present time, do not produce aspen shakes commercially. Stick with jack pine (best option) or lodgepole pine. Wait until additional field exposure data is available regarding aspen before deciding whether to develop this species for roofing shakes.

2. Improve shake quality. The quality of the sample shakes utilized in this research project is not sufficient for a premium roofing shake.

3. Minimize flat grain in shakes. Maximize vertical grain. Keep any flat sawn portions away from the center of the shake (more than 1.5 inches from center of shake). Flat grain shakes will split much more than edge grain shakes.

4. Keep butt thicknesses at 3/4" or greater.

5. Maintain shake widths between 4" and 8". No shakes wider than 8".

6. Eliminate black ring knots. They are *not acceptable* in any circumstance.

7. Eliminate pith.

8. Minimize other knots. Tight knots are acceptable in limited quantities.

9. Manufacture 24" shakes. A defect free (Number 1) shake can be applied in two courses. A lower quality (Number 2) shake will require three courses.

10. Use a roofing felt underlay system.

7.2 Strategic Recommendations

1. Initiate an Alberta Shake Manufacturers Association. The purpose of the association would be to promote Alberta pine shakes jointly (joint promotional material), to establish common grade rules, and to standardize the CMHC building material evaluation reports related to pine shakes.

2. Initiate a shake inspection and certification program in cooperation with the Alberta Forest Products Association. Shake production which meets established grade rules would be identified by stamps or certificates. AFPA inspectors would perform mill inspections, and would have the authority to remove grade stamps (or certificates) if production did not meet the established grades.

3. Concentrate initial marketing efforts in the local marketplace (i.e. Alberta, Saskatchewan, and Manitoba).

4. Develop a joint marketing approach for the United States. Seek and obtain U.S. building code approval (or proxy).

5. Continue to install and study test roofs in Alberta, and at the Hudson research site in Texas.

6. Continue to investigate preservative treatments (both dip and pressure treatments). The ongoing field trials established by this project will provide useful information regarding Cunapsol (water borne copper napthenate). Other treatments should also be investigated.

APPENDIX A. EVALUATION METHODS AND CRITERIA

Each row of shakes was numbered consecutively from bottom to top, the lowest row designated as 1. Within each row, individual shakes and shingles were numbered consecutively from left to right. For example, the leftmost shingle in the bottom row was identified as 1-1.

Except for the top row, which was comprised of short lengths of shakes, all shakes that were at least 4.0 inches wide and exposed to the weather were monitored. Each shake or shingle was examined for the following characteristics:

- **Width**
  The shortest distance between edges, across the butt of the shake or shingle when that shake or shingle is lying flat, i.e. not cupped or curled. Width was measured to the nearest 0.1 inch. The width of individual shakes was measured only at time of construction.

- **Curling**
  Elevation of the entire butt from the deck due to a concave bending of the entire shake or shingle. Where curling (snowshoe effect) occurs, one or more edges may be lifted further than the midsection of the shake. The minimum distance that shake has lifted from the respective shake below it was measured in 0.5 inch increments.

- **Cupping**
  Elevation of one or both edges at the butt of the shake. For cupping, the distance that edges of a shake had lifted above its respective center was measured in 0.25 inch increments. This distance was determined, at the butt end, by laying a straight edge from edge to edge on top of the shake. The vertical distance from the line connecting the two edges to the top center of the shake was recorded as elevation due to cupping.

- **Bowing**
  The reverse of cupping. The central portion of the shake is elevated higher than the edges. Distortion due to bowing was also measured in 0.25 inch increments.

- **Checks**

  Small, narrow fissures on the weather side of the shake that did not appear to penetrate the entire thickness of the item. The number of fissures per shake or shingle could not be easily counted; therefore, the incidence of checking was recorded by distribution as follows:

Rating	Incidence of Checking
0	None observed.
1	Light (less than 33 % of surface area)
2	Medium (33 - 66 % of surface area)
3	Heavy (67% or more of surface area)

- **Grain Separation**

  Large fissures on the weather face of each shake that appeared to penetrate the thickness of the shake but did not extend to the butt. The number of grain separations on the weather side of each shake was recorded without reference to the length of the individual fissures.

- **Splits**

  Fissures that penetrated the entire thickness of the shake or shingle extending to the butt. Splits were subdivided into two groups:

  Minor splits: Splits observed on the butt end of each shake that did not run the entire length of the weather face. The number of minor splits observed on the butt end of each shake was recorded.

  Major splits: Splits observed on the butt end that ran the entire length of the weather face. The number of major splits on each shake was recorded.