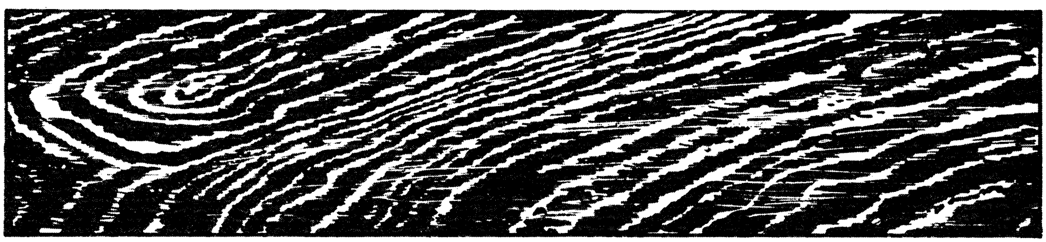
NC-16
RP
cop. 2

U. S. FOREST SERVICE
RESEARCH PAPER NC-16
AUGUST 1967

HARDWOOD SIDING PERFORMANCE



GLENN A. COOPER

NORTH CENTRAL FOREST EXPERIMENT STATION
D. B. King, Director
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

Contents

HARDWOOD SIDING PERFORMANCE

By

GLENN A. COOPER

Introduction

After 6 years of tests on a noninsulated storage building, yellow-poplar siding had performed better than siding made from five other hardwood species. Tongue-and-groove siding outperformed board-and-batten siding or horizontal clapboard, and siding treated with a water repellent and pentachlorophenol was superior to siding treated with penta alone. Red oak was a close second to yellow-poplar in performance and cost slightly less to install. Beech gave the poorest service; and soft maple cost the least per square foot. Generally, for all species tested, the most severe types of failure were opening of vertical joints between boards and splitting of the siding boards and battens.

Before 1875, hardwoods were the chief construction woods in the Midwest. When softwood lumber became readily available, the use of hardwoods diminished. Today relatively small amounts of hardwoods are used for construction, even where supplies are plentiful.

The declining use of hardwoods was due mainly to difficulties in nailing, seasoning, and painting them compared to softwoods. However, portable pneumatic nailers, improved seasoning techniques, and new finishes have eliminated some of these difficulties. Although hardwoods are not likely to replace large volumes of softwoods for construction, they can be used to a greater extent than at present. They must, however, be used properly or they will not perform well.

NOTE: *The author is Associate Forest Products Technologist, North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture, St. Paul, Minn. He is headquartered at the Station's field office in Carbondale, Ill., which is maintained in cooperation with Southern Illinois University.*

The Test

On the 124-foot-long north and south sides of our test building we installed vertical board-and-batten and tongue-and-groove panels made from yellow-poplar and red oak, and board-and-batten panels made of hickory, beech, sycamore, and soft maple.

For each yellow-poplar and red oak panel, one-third of the boards were dipped 3 minutes in a 5-percent solution of pentachlorophenol in mineral spirits with a water repellent, one-third were dipped 3 minutes in a pentachlorophenol solution without a water repellent, and one-third were installed untreated.

For each beech and hickory panel half of the boards were soaked 3 minutes in the water-repellent penta solution and half were installed untreated. And for the sycamore and soft maple panels, half of the boards were soaked in penta and the remainder were left untreated.

On the 40-foot-wide ends of the building (east and west exposures) we tested panels of yellow-poplar and red oak horizontal clapboard siding. Half of the boards for each panel were treated with water-repellent penta and half with penta. We installed elm board-and-batten siding in the gables, and tongue-and-grooved cottonwood and ash in 10- by 12-foot sliding doors. Half of the boards were treated with penta and half were untreated (fig. 1, table 1).

Poles on 16- and 12-foot centers supported oak and hickory horizontal girts (ribbands) 3 feet apart on the side walls. Studs on the end walls were on 2-foot centers. Siding was installed from 4 inches above grade to the soffit at 12 feet, 4 inches. There were no gutters, and the roof overhang was 8 inches, so the siding was exposed to sun and rain.

The boards in the board-and-batten siding were from 3½ to 7½ inches wide and ¾ inch thick. Most of the siding boards and battens were full-length (12 feet); but to meet defect limitations[1] and obtain better yields we also used some 3-, 6-, and 9-foot boards and battens butted and staggered on the girts. Boards were spaced ¾ inch apart, and the ¾-inch-thick by 2½-inch-wide battens were centered

[1] *Defect limitations: All siding used was free of decay, loose knots, knot holes and other holes larger than ¼ inch in diameter, splits, shake, exposed pith, and sloped grain in excess of 1 in 10. Allowable defects were pin, shot, and worm holes up to ¼ inch in diameter; burls, stain, streak, seasoning checks, enclosed pith, tight knots up to 1¼ inches in diameter, and tight knot clusters.*

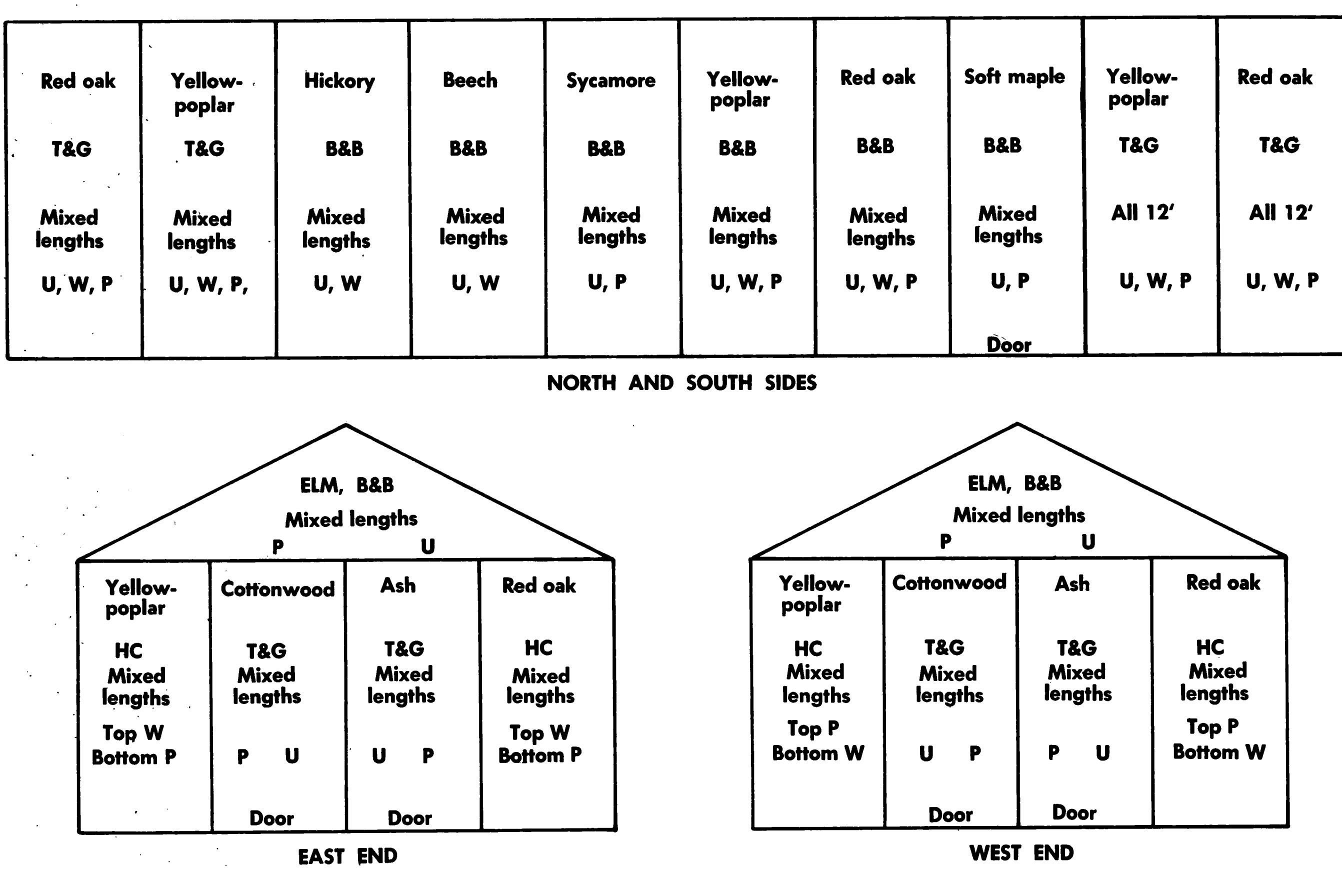


Figure 1.—Species, style, board length, treatment, and location of the test panels. Styles were T&G (tongue-and-groove), B&B (board-and-batten), and HC (horizontal clapboard). Treatments were P (pentachlorophenol), W (water-repellent penta), and U (untreated).

Table 1.—The variables tested

Species	Siding style	Treatment[1]
ON THE NORTH AND SOUTH SIDE WALLS (PRIMARY TEST)		
Yellow-poplar and red oak	Board-and-batten	Untreated Penta WR penta
	Tongue-and-groove	Untreated Penta WR penta
Beech and hickory	Board-and-batten	Untreated WR penta
Sycamore and soft maple	Board-and-batten	Untreated Penta
ON THE EAST AND WEST END WALLS (SECONDARY TEST)		
Yellow-poplar and red oak	Horizontal clapboard	Penta WR penta
Ash and cottonwood	Tongue-and-groove	Untreated Penta
American elm	Board-and-batten	Untreated Penta

[1] Penta = pentachlorophenol; WR penta = water-repellent pentachlorophenol.

over the gap. Boards were surfaced on the heart side and installed with the rough bark side to the weather. The boards were nailed to each girt with two 8-penny, 2½-inch, galvanized, threaded nails; and battens were fastened to each girt with one 10-penny, 3-inch, galvanized, threaded nail.[2] Board nails were 1¾ to 5 inches apart within each girt.

Tongue-and-groove siding was ¾ inch thick and 3⅝, 5⅝, or 7⅝ inches wide. Both sides were surfaced. Tongues were ⅜ inch wide by ⅛ inch thick, and grooves were 7/16 inch deep. Two panels each of oak and yellow-poplar were made from 12-foot boards. The other panels were of mixed-length boards (3-, 6-, 9-, and 12-foot). Butt joints were staggered, and the bark side was faced to the weather. The 3⅝-inch and 5⅝-inch boards had two nails at each girt, and the 7⅝-inch boards had three nails. Spacing between outside nails varied from 1¾ to 5 inches.

Horizontal clapboard siding was 13/16 inch thick, 7½ inches wide, and 4, 8, or 10 feet long. It was surfaced one side and installed with the rough face to the weather with a 1-inch overlap. Boards were nailed to each stud with one 8-penny 2½-inch galvanized threaded nail about 1¼ inches above the bottom edge of the board.

All siding studs and girts had about a 16-percent moisture content when installed. This is approximately the mean equilibrium moisture content for wood in outdoor use in southern Illinois. During the test, the moisture content of the siding varied from 12 to 20 percent; and at the final inspection, after a dry summer and fall, it averaged 12 percent.

Immediately after installation, the siding was brush-coated with the Forest Products

[2] *All siding nails were furnished through the courtesy of Threaded Nails, Inc., Skokie, Ill. A 0.125-inch drill was used to predrill for both the 8d and 10d nails which were 0.148 inch and 0.153 inch in root diameter, respectively.*

Laboratory natural stain,[3] containing double-strength cedar color pigment.

Method of Evaluating Performance

The initial condition of the siding was recorded after it was installed in October 1960. Subsequent inspections were made each May and October for 6 years, and spot inspections were made after heavy rain and wind storms.

We evaluated siding performance by four criteria: weather-tightness of joints, amount of board splitting, number of popped nails, and amount of checking. Decay, originally considered a principal criterion, occurred so seldom that it was relegated to a group of secondary criteria; these included water staining on the unfinished interior sides of the boards, finish performance, and resistance to woodpecker damage.

Weathertightness was determined by counting the leaky joints, by measuring the lineal inches of no contact (light leaks) between boards or between boards and battens, and by noting the extent of water stain on the inner face of the siding panels.

Splitting frequency was rated by the total length of splits longer than 4 inches divided by the total length of boards and battens.

Checking was subjectively rated from 0 to 100 percent: A siding panel with only a few superficial or short checks was considered 10 percent checked. If a test panel contained checks in every square foot or had many scattered deep, wide, and long checks, it was rated as 90 percent checked. Other ratings were scaled proportionately.

Fastener tightness was rated by the number of popped nails versus the total number of visible nails in a panel (some nails were covered by battens or a frieze board). If the underside of a nail head was not in contact with the board surface, it was considered popped.

[3] *U.S. Forest Service, Forest Products Laboratory. Forest Products Laboratory natural finish. Report No. 2096, 9 pp., illus. 1957.*

All performance characteristics measured by the secondary criteria were recorded by photographs and notes.

Species Differences

On the North and South Sides

Only untreated board-and-batten panels were installed for all six species tested on the north and south walls. Therefore, the following species comparisons refer only to these panels.

Yellow-poplar performed the best (table 2): Less than 3 percent of the total joint length leaked, splits were less frequent, nail pops fewer, and checking less severe than in any of the other species. Furthermore, the yellow-poplar wood was stable, it developed very little warp or raised grain, and it held the finish better than the other species.

Red oak siding ranked a close second to yellow-poplar: Less than 4 percent of the total length of joints leaked. Splits were more frequent in the red oak than in the yellow-poplar, but most splits were less than 6 inches long and were located at the bottom of the panels where the horizontal girt prevented through-the-panel leakage. About 2 percent of the nails were popped, and most of them were in battens. The red oak was all flat sawn and, as might be expected, checked considerably — 50 percent — about the rays. However, all checks were short and shallow.

Hickory was intermediate in performance. Thirteen percent of the total joint length in the panels leaked. These leaks were chiefly due to warping of the battens. Six percent of the hickory siding parts had splits, slightly more of them in the battens than in the boards. Three percent of the nails popped, most of them in battens (fig. 2). Eighty percent of the panel surface area was checked, and the checks were longer and deeper than in red oak.

Table 2.—Percent of failures in untreated board-and-batten siding for six hardwood species, by type of failure

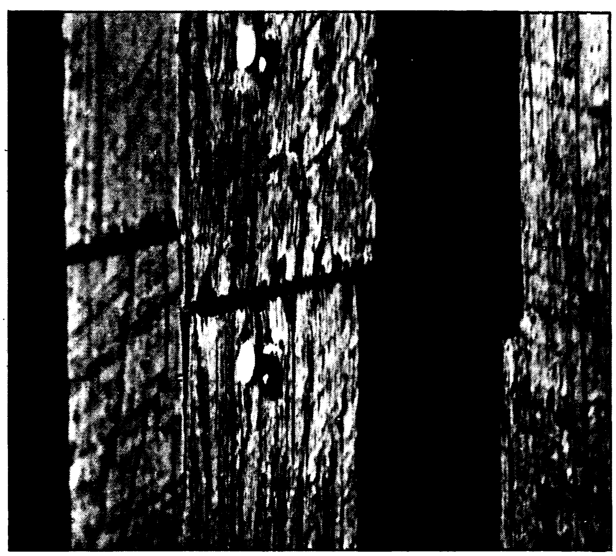
Species	Type of failure			
	Leaks 1/	Splits 2/	Nail pops 3/	Checks 4/
Yellow-poplar	3	2	2	25
Red oak	4	5	2	50
Hickory	13	6	3	80
Soft maple	13	21	4	60
Sycamore	30	20	6	60
Beech	40	8	7	90

1/ Length of leaky joints between boards divided by total length of joints between boards x 100.

2/ Number of splits over 4 inches long divided by total length of boards in panels x 100.

3/ Number of popped nails divided by total number of exposed nail heads in panels x 100.

4/ Number of square feet of checked panels divided by total square feet in panels x 100. Exterior side only.



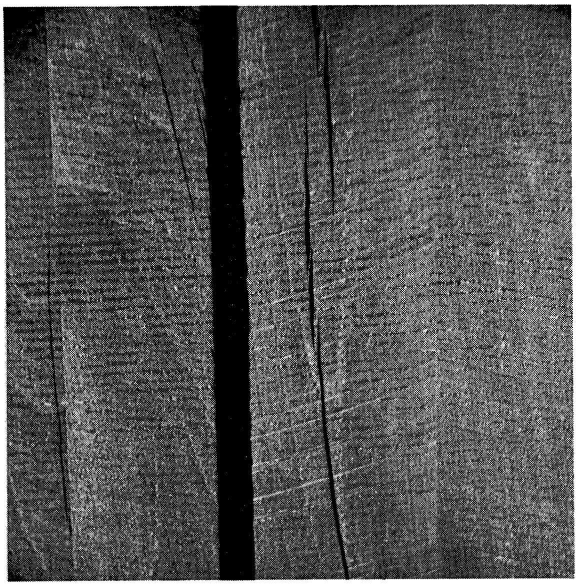
F-516581

Figure 2.—Popped nails in hickory battens. Most popped nails were not this far out.

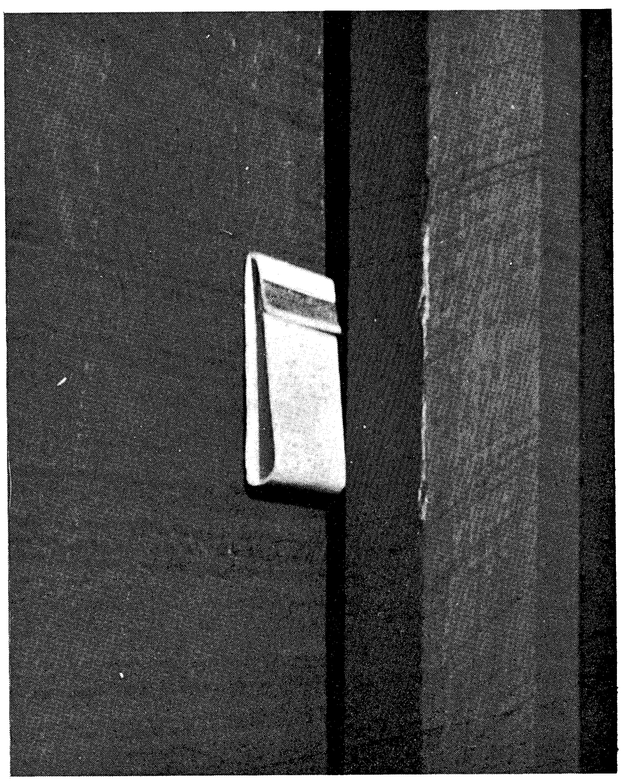
Soft maple siding was also intermediate in performance. About 13 percent of total joint length leaked, chiefly due to warp of both boards and battens. Soft maple split more than the other species tested (21 percent of the boards or battens contained splits), and most of the splits developed at the nails in battens. Four percent of the nails were popped, with about the same frequency in boards as in battens. Sixty percent of the panel surface area had short, shallow checks and occasional long, deep checks.

Sycamore performed noticeably poorer than any species except beech. The untreated sycamore joints leaked along 30 percent of their total length, partly because of considerable warp of the battens. Nail popping (6 percent) and checking (60 percent) were about the same as for soft maple. Splitting (20 percent) occurred mainly as a few long splits (fig. 3).

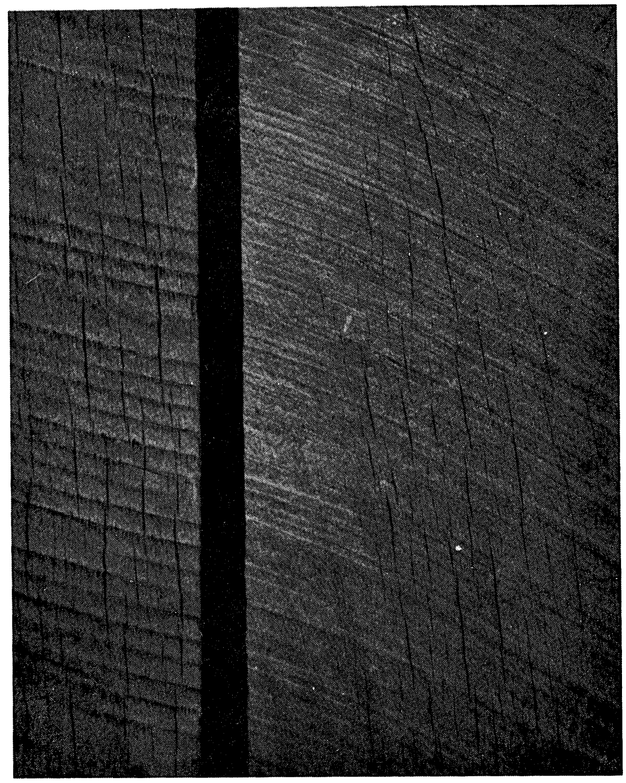
Beech performed poorest of the six species by all test criteria except splitting where it ranked fourth. Leaks occurred along 40 percent of total joint length and were larger than in the other woods due to greater warpage of the boards and battens (fig. 4). Checks were of moderate size compared to the other species, but 90 percent of the test surface had many closely spaced checks (fig. 5).



F-516582
Figure 3.—Sycamore board-and-batten siding, untreated, south wall, with long mid-board splits.



F-516583
Figure 4.—This beech batten bowed over ¼ inch away from the adjacent boards.

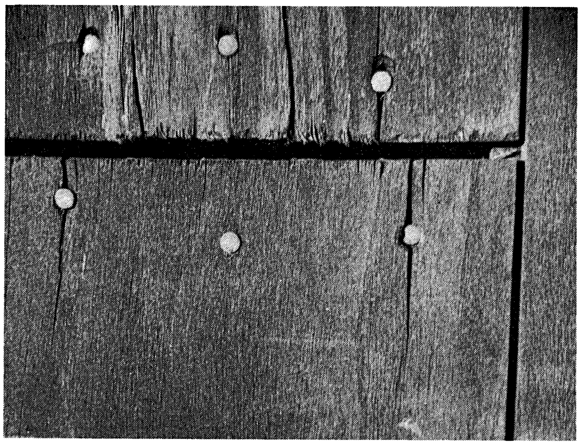


F-516584
Figure 5.—Checking in beech board-and-batten siding was extensive but did not reduce the utility of the siding.

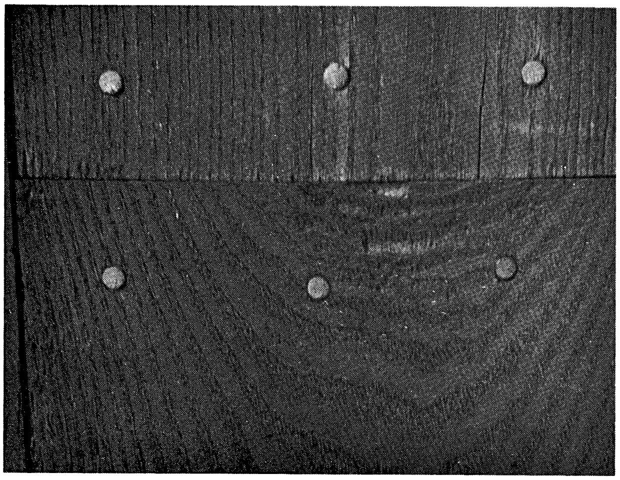
On the East and West End Walls

On the east and west end walls the yellow-poplar and red oak horizontal clapboard siding performed better than either the tongue-and-groove ash and cottonwood or the board-and-batten elm in all respects except weathertightness. However, siding style, not species, caused more leaks in the red oak and yellow-poplar.

The cottonwood was inferior to the ash because it warped badly. In two instances tongue-and-groove joints in cottonwood panels became disengaged, causing a leak. Furthermore, the cottonwood had more splits and nail pops than the ash. Longitudinal shrinkage (probably due to concentrations of tension wood) was apparent at the butt joints in the cottonwood but not in the ash (figs. 6 and 7). This longitudinal shrinkage



F-516585
Figure 6.—This ¼-inch butt joint gap in cottonwood tongue-and-groove siding resulted from excessive longitudinal shrinkage, particularly in the upper board. The indentation of the nail at upper right, and the splitting at nails is further evidence of longitudinal change.



F-516586
Figure 7.—Tight butt joints in ash with the same treatment and exposure as the cottonwood in figure 6. Note the absence of end splits at the nails.

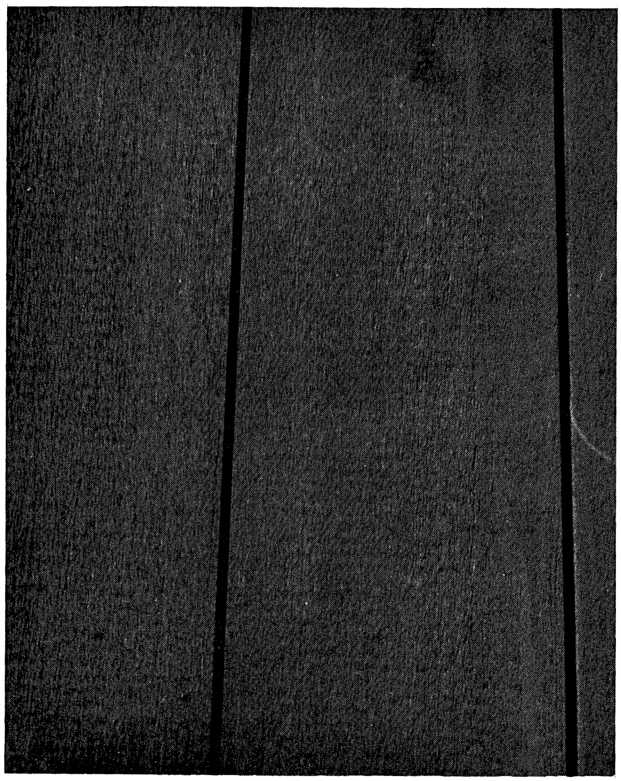
caused splits at the nails. The cottonwood also was more cupped than the ash.

Elm board-and-batten siding in the gables was unsatisfactory because most of the battens warped, creating joint leaks.

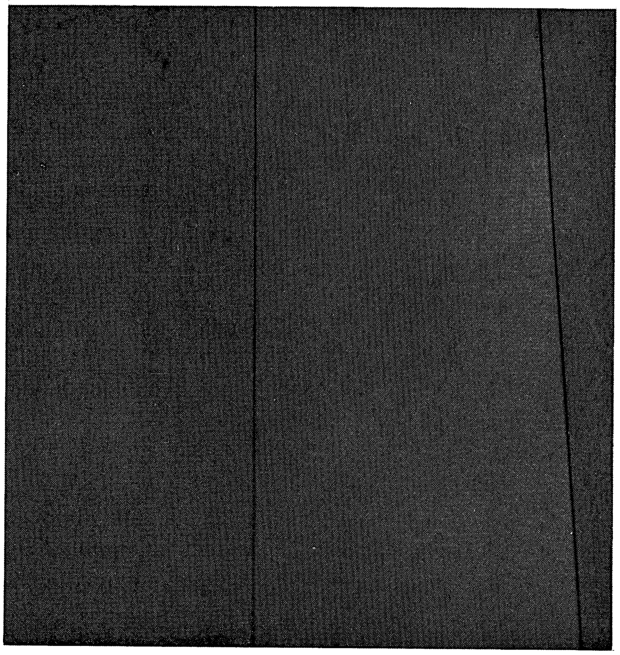
Style Differences

Siding style comparisons are limited to the red oak and yellow-poplar because the other woods were tested in one style only. Furthermore, to avoid confounding style and treatment effects on performance, style comparisons are limited to the panels treated with penta and water-repellent penta (horizontal clapboard was not tested untreated—table 1).

Differences in the red oak and yellow-poplar siding styles were clearly evident. Tongue-and-groove siding was the most watertight (figs. 8 and 9). Only one leak in the 16 test panels occurred, and this was due to tongue breakage during installation. There was less water staining on the inside of these panels than in the other styles because the



F-516587
Figure 8.—Yellow-poplar tongue-and-groove siding, water repellent treatment on the south wall. The boards have shrunk exposing 3/16 inch of tongue, but the joint is tight.



F-516588

Figure 9.—Yellow-poplar tongue-and-groove siding, water repellent treatment on the north wall. Shrinkage has exposed less than 1/16 inch of tongue, joints are tight, and checking is almost invisible.

joints remained tight. Furthermore, after rain storms there was no free water on the inside of the tongue-and-groove siding, whereas there was on the other sidings.

Board-and-batten siding did not perform nearly as well as the tongue-and-groove siding. Battens that warped or were loosened by nail pops did not remain flush to the boards (see fig. 4); and because nails were at 3-foot intervals, any warp caused a leak. Boards in the board-and-batten siding were not held in place as tightly as tongue-and-groove boards and therefore warped more. Furthermore, after the boards and battens were dressed on one side and installed on the girts, the sawn faces of adjacent boards were not always in the same plane. Thus, a batten might be tight to one board but not to the other, and a leak would result.

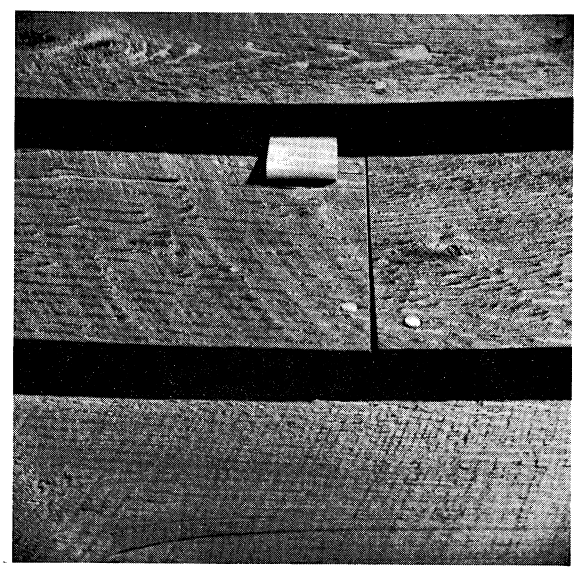
Horizontal clapboard, planed on one face only and installed with the rough-sawn face to the weather, leaked even more than the board-and-batten siding. Every joint showed light between the rough exterior face of one board and the dressed interior face of the board above in both the red oak and yellow-poplar panels (fig. 10), and wetting was evident on the inner faces after rains.

Water staining and wetting of the inner faces of the panels was also associated with the number of butt joints in the siding, regardless of style. Although boards were butted as tightly as possible during installation, some of these joints separated. Thus, in panels containing shorter than full-length boards there was more water staining than in panels of 12-foot boards.

Besides leakage, nail popping and splitting differed among siding styles. Board-and-batten siding had more pops and splits than the other two styles. The splits were most frequent in the battens, partly because of longitudinal shrinkage and stress concentration around the nail holes.

Treatment Differences

The water-repellent penta treatment was better than penta or no treatment for reducing leaks and splits but did not always



F-516590

Figure 10.—This yellow-poplar horizontal clapboard siding joint was open about ⅛ inch.

Table 3.—Frequency and type of failure of untreated and treated hardwood siding (north and south walls)

Type of treatment	Types of failures			
	Leaks[1/]	Splits[2/]	Nail pops[3/]	Checks[4/]
	Percent failures			
Penta and water repellent	5	8	3	45
Penta	10	14	3	40
No treatment	12	13	4	50

1/ Length of leaky joints between boards divided by total length of joints between boards x 100.

2/ Total length of splits over 4 inches long divided by total length of boards in panels x 100.

3/ Number of popped nails divided by total number of exposed nail heads in panels x 100.

4/ Number of square feet of checked panels divided by total square feet in panels x 100. Exterior side only.

retard nail popping and checking (table 3). Differences in performance were small between penta and no treatment. However, because of interactions between species and treatments, treatment effect is best understood by examining differences by species.

Treated yellow-poplar panels had fewer leaks and checks than the untreated panels, but splitting and nail-popping were not reduced by treatment. In the red oak panels leakage and checking apparently were not reduced by treatment. Splitting of red oak boards was least in the penta treated panels and somewhat greater for the untreated and water repellent-penta treated panels. Nail-popping in red oak appeared to be reduced by both treatments. Performance of hickory was not affected by treatment, but penta-treated soft maple had fewer splits and checks. In untreated beech board-and-batten panels nail-popping was less than in the water-repellent treated panel — the only case where a treated panel had more nail pops than an untreated panel. For sycamore there was less nail-popping in the water repellent-penta treated panel, but there was little difference among the other panels.

An outstanding difference due to treatments was the amount of water stain on the inside of the panels (see fig. 11). In all siding the water repellent-penta treated boards were almost free of stain, whereas all the untreated and penta treated panels had considerable stain on the inner faces.

One untreated sycamore board on the north wall had decay near the bottom girt inside the building. Decay also has started in one untreated cottonwood and one untreated ash board (not part of the major test) at both ends of the building. The areas of decay started at barely visible sticker stains and are about 2 inches square. These areas showed incipient decay after 3 years, and after 6 years are very soft.

Another treatment difference occurred in the east gable of board-and-batten elm. Half

F-516589

Figure 11.—Water has stained the inner faces of the penta-treated (left) and untreated (right) portions of this red oak mixed-length tongue-and-groove siding. The water-repellent penta-treated portion (center) has no stain. Free water was not observed on any of the portions after rains. Stain is therefore attributed to moisture wicking through butt and edge joints.

the gable was penta-treated and half was untreated. In 1962 woodpeckers attacked the battens. One batten on the treated side had one pecked spot; all battens on the untreated half had several pecked spots at the edges.

As judged by the four performance criteria, the treated panels were better than the untreated panels. If, in addition, water staining on the inside is considered, the water repellent preservative has been the best of the three treatments.

Differences Between the North and South Exposures

The general appearance of the north wall has always been better than that of the south wall. Leaks, splits, nail pops, and checks have been fewer and the finish has faded less.

	Percent of failures	
	North wall	*South wall*
Leaks	8	11
Splits	8	16
Nail pops	2	4
Checks	45	50

Joint leaks on the south wall, initially much more numerous than on the north wall, are now only slightly more numerous but noticeably longer. The longer leaks are due primarily to more nail loosening, warp, and shrinkage (figs. 2 and 4). This is true regardless of species or treatment, but it is more evident in beech and sycamore than in the other species. Furthermore, water stain on the inside was first noticed on the south wall, and it continues to be more extensive there than on the north wall.

Siding Cost Differences

Besides studying siding performance, we recorded costs. Considering our lumber yields, current lumber prices, and estimated labor costs, the red oak and yellow-poplar tongue-and-groove siding cost less ($0.35 and $0.38 per square foot) than board-and-batten siding made of the same woods ($0.37 and $0.41 per square foot) (table 4). But, if low cost is the main criterion, soft maple board-and-batten siding at $0.28 per square foot ranked first, primarily because soft maple No. 1 Common lumber cost the least.

We estimate that yellow-poplar siding cost $0.08 per square foot less than similar siding can be made from Douglas-fir C Select lumber. Furthermore, yellow-poplar tongue-and-groove siding performed well, held a finish satisfactorily, and did not develop raised grain as Douglas-fir sometimes does. Installed ¾-inch Douglas-fir AC exterior plywood siding is estimated to cost about $0.375

Table 4.—Cost of ¾-inch siding by style and species

Style and species	Lumber cost per 1,000 sq. ft.1/	Milling yield2/	Per thousand sq. ft. of coverage: Required mill input3/	Material cost	Milling cost4/	Installation labor costs5/	Total installed cost	Total cost rank
	Dollars	Percent	Sq. ft.	Dollars	Dollars	Dollars	Dollars	
Board-and-batten								
Red oak	135	61.9	2,019	272.57	24.23	75.00	371.80	6
Yellow-poplar	150	60.0	2,083	312.45	24.97	75.00	412.42	9
Beech	127	62.4	2,003	254.38	24.04	75.00	353.42	5
Hickory	148	75.3	1,660	245.68	19.92	75.00	340.60	3
Sycamore	110	65.9	1,897	208.67	22.76	75.00	306.43	2
Maple	110	74.4	1,678	184.58	20.14	75.00	279.72	1
Tongue-and-groove								
Red oak	135	54.5	1,908	257.58	28.62	65.00	351.20	4
Yellow-poplar	150	53.8	1,993	289.95	29.00	65.00	383.95	8
Douglas-fir	320	85.0	1,176	393.96	0.00	65.00	458.96	10
Plywood								
Douglas-fir	335	100.0	1,000	320.00	0.00	45.00	375.00	7

1/ All 1-inch No. 1 Common lumber except: maple--No. 1 Common, worm holes no defect; Douglas-fir--C Select; and Douglas-fir plywood--AC. Hardwood prices are local mill prices for rough air-dry lumber. Softwood prices are local retail yard prices.

2/ Actual production yields for hardwoods. Softwood yields are estimated from Construction Estimates Guide, 1963.

3/ Anticipates siding milling losses and loss in coverage due to board-and-batten overlap and tongue-and-groove interlocking.

4/ Board-and-batten siding $12.00/M sq. ft.; tongue-and-groove $15.00/M sq. ft.

5/ Carpenter and helper. From Building Construction Cost Data, by Robert S. Means, 1966.

per square foot, which is about the same as our yellow-poplar tongue-and-groove siding cost, and is $0.024 per square foot more than our costs for red oak tongue-and-groove siding.

Recommendations

From this study, the following hardwood siding recommendations are made:

1. For maximum weathertightness use full-length, vertical tongue-and-groove yellow-poplar or red oak siding, dip-treated in a water-repellent preservative, and installed bark side out.

2. If rough vertical board-and-batten or horizontal clapboard siding is preferred, the lumber must be accurately milled to insure boards of the same thickness. To insure tight joints it is better to use boards dressed on both sides and sacrifice the good finish retention provided by rough faces. Red oak and yellow-poplar are both suitable for board-and-batten siding.

3. Where vertical siding is installed on horizontal nailing girts, the girts should be closer than 3 feet on centers, particularly with board-and-batten siding. We recommend placing girts on 2-foot centers.