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University of Minnesota
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United States Department of Agriculture

Aspen
Availability, Properties, and Utilization

R. P. A. Johnson
Forest Products Laboratory

Joseph Kittredge, Jr.,
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and

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ASPEN
AVAILABILITY, PROPERTIES, AND UTILIZATION

R. P. A. Johnson, Joseph Kittridge, Jr., and Henry Schmitz

SUMMARY

Aspen in Minnesota, Wisconsin, and Michigan occupies 21,000,000 acres, which is more area than occupied by any other forest type in the Lake States. Of this total acreage, 17,000,000 acres may be expected to produce merchantable yields. About 8,000,000 acres have stands averaging larger than 3 inches in diameter, and not more than 1,200,000 acres have stands averaging over 6 inches in diameter. The volume in stands over 3 inches in diameter is estimated at 29,000,000 cords of which about 12,000,000 cords are in stands over 6 inches in diameter. The volume will increase for 20 to 40 years owing to the large area of thrifty young growth that will become merchantable.

Aspen is a rapid-growing, short-lived tree and should usually be cut at an age of about 50 years. At that age small areas of well-stocked stands on average sites may be expected to yield 39 cords per acre, net scale. Over large areas the stands can be expected to yield between 5 and 20 cords to the acre, owing to openings and understocking.

The aspen tree is highly susceptible to decay. At 50 years of age about 10 per cent of the merchantable volume has advanced decay; in older stands the percentage is higher and in younger stands lower. In stands more than 50 years old, decay increases rapidly.

The stumpage value of aspen at present is low but it has been on an upward trend. Present prices range from 25 cents to $1 a cord, and from $1 to $2 per thousand board feet.

At present young stands of aspen are considered to be of little value. Large areas of 10-year-old aspen if held for 40 years, will earn about 4 per cent compound interest on the costs if the stumpage is then worth $1 a cord. This estimate of earning, which would be made by a company that plans to hold young growth for a future cut, is based on the most probable combination of ages, costs, site qualities, and stumpage values involved in growing a crop of aspen.

The clear wood of aspen has a number of excellent properties, the most desirable of which are softness, uniform texture, white color, light weight, ease of gluing, and low shrinkage. Aspen is as soft as basswood and softer than yellow poplar—two hardwoods noted for their softness. The exceedingly fine, uniform texture of aspen, combined

with softness, make it easy to work. Aspen wood weighs less than basswood and more than cottonwood, and of our native woods is one of the easiest to glue. Aspen shrinks less than basswood, but more than northern white pine. There are few hardwoods that do not swell and shrink more with changes in moisture content than does aspen. The combination of low shrinkage and straightness of grain permits aspen to stay well in place.

Compared with woods commonly used for structural purposes, aspen ranks low in most strength properties. It has the same bending strength as northern white pine but less than eastern hemlock. In stiffness and compressive strength (endwise), it is inferior to basswood but superior to northern white cedar. Aspen should not be used where bending or compressive strength is important.

Aspen is tough for a soft, lightweight wood; more so than basswood or yellow poplar, and as tough as eastern hemlock. The toughness of aspen is a desirable property in some of the uses to which lightweight, soft wood is put, but it does not adapt aspen to uses where toughness is the most important requirement.

Aspen wood has about the same nail-holding power as that of basswood and cottonwood. The softness and uniform texture of aspen, however, result in but little loss of nail-holding power from nails splitting the wood. Aspen is easily split with an ax owing to its straight grain and low strength across the grain. It splits with about the same ease as eastern spruce.

Aspen can be pulped by any of the standard processes. The yield of pulp per cord compares favorably with that of the commonly used softwoods. It is of an excellent color and is easily bleached, but is not as strong as pulp obtained from the softwoods commonly used.

The use of aspen for pulp is increasing. At present it is used principally for the production of soda pulp. Some is ground for newsprint. It can be used for the production of sulphite pulp, either alone or mixed with softwood.

Data on the use of aspen are meager and fragmentary. It is used almost everywhere it is found, but is cut in large quantities only in the Lake States. Information regarding the amount cut and its uses is difficult to obtain owing to the practice of statistical agencies of combining statistics on aspen with those on cottonwood.

A large amount of aspen is cut into lumber, which is used in the manufacture of many articles such as boxes, crating, and planing mill products. It is just beginning to be used for interior and exterior trim, flooring, planking, and for other building purposes. Except in a few industries, the species is almost unknown. Match, woodenware, and novelty manufacturers in the United States are experimenting with aspen, but in European countries it has been used for matches for many years. Aspen has been used successfully in the manufacture of clothes pins. Furniture and veneer panel manufacturers in the United States have not yet recognized the possibilities of aspen for core stock, but the adaptability of the wood to such use has long been recognized in Europe.

In considering the possibility of expanding the market for aspen lumber, past experience with other so-called little-used woods offers encouragement. At least three woods, now accepted and extensively used in the United States, were until a few years ago, in about the same state of development that aspen is.

Aspen is better known to users of wood in the form of logs, bolts, and like products than in the form of lumber. Manufacturers of excelsior accept it as one of the woods best adapted for high-grade excelsior. When treated with preservatives, it makes an acceptable crosstie in tracks not subject to heavy traffic. For years farmers of the Lake States have used it for fuel and for posts. Small amounts are used for mine timbers, principally in round form and some, for cooperage.

AVAILABILITY[1]

Economic and Silvicultural Importance

The abundance and importance of aspen, often called "popple," in the northern parts of the Lake States usually are not recognized because a large part of the supply is in young stands that have followed recent fires and consequently looks like brush rather than tree growth (Fig. 1). Aspen occupies more area of forest land in the Lake States than any other tree species. It is estimated that aspen covers one third of the forest area in northern Michigan and two-thirds in Wisconsin and Minnesota. The merchantable volume in the existing stands is relatively small compared with the amount that will become available in the next 30 to 50 years. At that time, aspen will be a much more important source of raw material for wood-using industries than it is at present. A company that can adapt its manufacturing processes for the utilization of aspen within the next few years has every prospect of being able to obtain an abundant supply of raw material for many years.

Altho aspen has been, and still is, considered an undesirable species, there is no reason to believe that it will continue indefinitely to be regarded unfavorably. In the days of white pine logging, Norway pine, maple, and yellow birch were likewise considered undesirable.

[1] The section which deals with the characteristics of the growth and stands of aspen, was written by Joseph Kittredge, Jr., senior silverculturist, Lake States Forest Experiment Station, St. Paul, Minn., except for the subsections and related species and on diseases, which were written by Henry Schmitz. Much of the material has been adapted from Minn. Expt. Sta. Tech. Bull. 60, "Forest Possibilities of Aspen Lands in the Lake States," in which it is treated in greater detail.

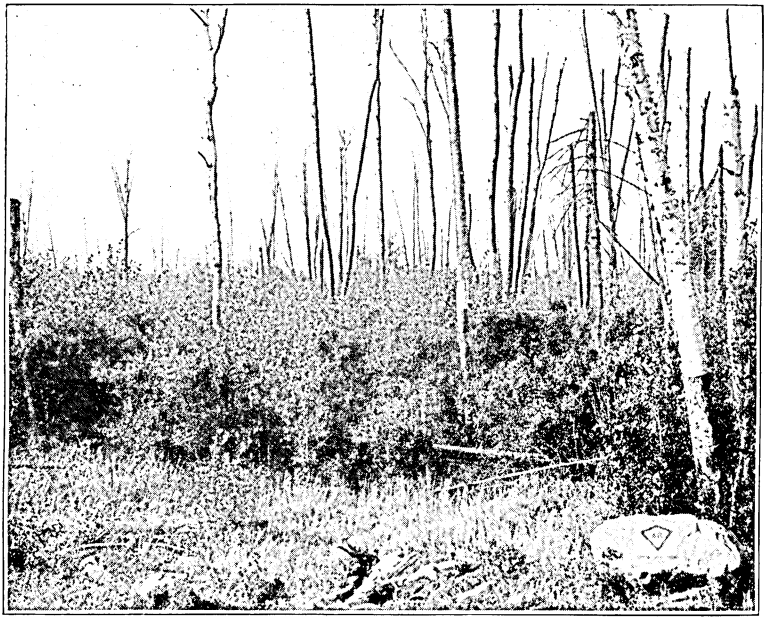

Fig. 1. "Brush," Five-Year-Old Aspen, Usually Considered Worthless

More recently hemlock was looked upon as a weed tree in the northern hardwood forest. Only a few years ago, jack pine was considered not worth cutting. Yet all of these species in turn have become marketable at prices that have justified large-scale commercial development. There is every reason to believe that aspen also will be cut and utilized to advantage. Aspen is useful and desirable for purposes other than the products it yields. It tends to maintain the forest soil in good condition. It serves as a nurse tree for the establishment of white pine and spruce reproduction. And finally, it provides its own fire insurance. Altho light fires will kill the part of the tree that is above the ground, the root system produces suckers prolifically after every fire and the new stand of suckers is more dense than the stand that was killed.

Aspen and Closely Related Woods

Aspens, together with cottonwoods and other poplars, not including yellow poplar, all belong to the genus *Populus*. In the Western Hemisphere, poplars are found from the Arctic Circle south to northern Mexico and Lower California, and from the Atlantic to the Pacific Coast. In the Eastern Hemisphere, poplars are found from the Arctic Circle to northern Africa, central China, and Japan.

In the more northerly parts of both hemispheres, the poplars form extensive forests. Chief among these are the aspen of North Amerca

(*Populus tremuloides*) and the European aspen (*Populus tremula*). The common North American aspen extends over approximately 112 degrees of longitude; the European, over 140 degrees; the two almost encircling the globe. Few trees have a wider distribution than these two species.

Aspens differ from cottonwoods in flower structure and not, as generally supposed, in the flattened leaf petiole. Many of the more common cottonwoods also have a flattened leaf petiole, a characteristic commonly ascribed to aspens.

Two species of aspen grow in North America. These are commonly known as aspen (*Populus tremuloides*) and large-tooth aspen (*Populus grandidentata*) and in the Lake States as popple or poplar. In the lumber and pulp industries, the two species are seldom separated. Several varieties of aspen (*Populus tremuloides*) are also recognized. The differences between the varieties are minor and of no concern to the lumberman, inasmuch as there are no distinguishable differences in the characteristics or properties of the wood.

Among the more important American relatives of the aspens are the swamp cottonwood (*Populus heterophylla*), balsam poplar (*Populus balsamifera*), northern black cottonwood (*Populus trichocarpa hastata*), eastern cottonwood (*Populus deltoides*), and cottonwood (*Populus sargentii*). The balsam poplar, or balm-of-Gilead, is the only one that grows extensively with the aspen in the northern part of the Great Lakes region.

Aspen Stands in the Lake States

Origin and life history of aspen stands.—In the old-growth forest, before cutting and slash fires, aspen must have been an uncommon and inconspicuous constituent of the forest. It probably occurred as an occasional small, suppressed tree, or group of trees, in the openings, particularly in the white pine and white spruce forests. As cuttings and fires removed the old growth and incidentally destroyed the few existing aspens, suckers came up from the roots in a radius of 25 or 30 feet around each of the stems that had been destroyed, and with 20 to 30 suckers to a stem. Every fire that burned over the area thus increased the density and the area of the aspen in the new crop. Almost all of the enormous area of aspen in the northern Lake States today has resulted from repetitions of this process.

The tiny "cotton"-tufted seeds of aspen are produced abundantly in most years on seed-producing trees. They are so light that it takes two or three million to make a pound; consequently they are carried long distances by the wind and germinate almost immediately if they fall on moist ground. Most of the seeds, however, never germinate, except in the occasional favorable season and place; or the frail seedlings die during their first year. Altho an insignificant part of the present aspen stands have originated directly from seed, seeding has been important in enabling the aspen to gain a foothold in new places so that scattered trees were widely distributed from which the suckers developed and spread as the old forest was removed.

The few seedlings which survive are likely to be destroyed by fire before they are 25 years old. The root systems are established, however, and a group of vigorous, rapid-growing suckers replaces each aspen that is killed. The new group occupies an area of about one fifteenth of an acre. Ten years later, more or less, the trees of this group are killed by another fire and the succeeding crop of suckers covers more than one fourth of an acre. After the fourth fire, the suckers from a single, original tree may completely and densely occupy an area of one acre. This process is significant because it could account for the presence of the aspen type on areas where aspen trees occurred at the rate of one per acre in the original forest and where four or more fires have burned subsequently. These two conditions have existed in the Lake States on very large areas, quite comparable with the area of the aspen type.

On small areas that escape fires, the aspen grows rapidly until about 50 years old. Many of the smaller trees are crowded out and killed in the competition in the dense stands. The fungus causing the common decay usually attacks the trees at or before this age. After 50 years, the decay increases, the vitality and growth of the trees decline, and few reach an age of 100 years. Some suckers start because the death of larger trees makes openings, but the suckers are usually few. Often balsam fir, pine, and spruce or maple and basswood replace the aspen at this stage and thus end the aspen cycle. More often it is renewed by cutting or fire in the early stages of development.

Present area.—The surveys of the Michigan Land Economic Survey, of the Wisconsin Economic Inventory, of Hansen in St. Louis County, Minnesota, of Sparhawk in Lincoln County, Wisconsin, and of the National Forests indicate that the aspen type occupies from one third to two thirds of the forest area in the northern Lake States. The total area has been estimated as 21,000,000 acres. A rough division of this area between the three states would give Minnesota 9,000,000, Wisconsin 7,000,000, and Michigan 5,000,000 acres. There is little evidence that the area of the aspen type will decrease appreciably in the next 50 years.

Distribution by sizes.—The existing surveys of a few counties indicate that 60 to 85 per cent of the aspen stands average from 0 to 3 inches in diameter, from 4 to 15 per cent between 3 and 6 inches, and from 0.1 to 11 per cent in stands more than 6 inches in diameter. These proportions vary in the different states and in different parts of the states. In the lower peninsula of Michigan there is less than 1 per cent of the aspen area covered by stands averaging more than 6 inches in diameter. In Minnesota as much as 10 per cent is probably occupied by such stands, and within areas like the National Forests which have been protected from fire, as much as 50 per cent. Wisconsin is probably intermediate between Michigan and Minnesota in this respect.

The manner of occurrence of the aspen of different sizes and different areas of stands is related to the history of the region. Aspen has come up most commonly on the former white-pine areas, which occupied a belt across north central Michigan, Wisconsin, and Minnesota. These areas were logged 30 to 50 years ago and a large proportion has since been taken up by settlers. Consueqently, aspen 30 to 50 years old is more commonly found in the white-pine belt in small units, frequently forming parts of farms. For this reason, it is not easy at the present time to find or block out large areas of aspen of merchantab'e size, altho there are such areas in places on old burns in northern Minnesota (Fig. 2). Likewise, young aspen, which has come up after recent fires and logging operations in the more northern parts of the region, occur in large areas where sizeable contiguous hold-

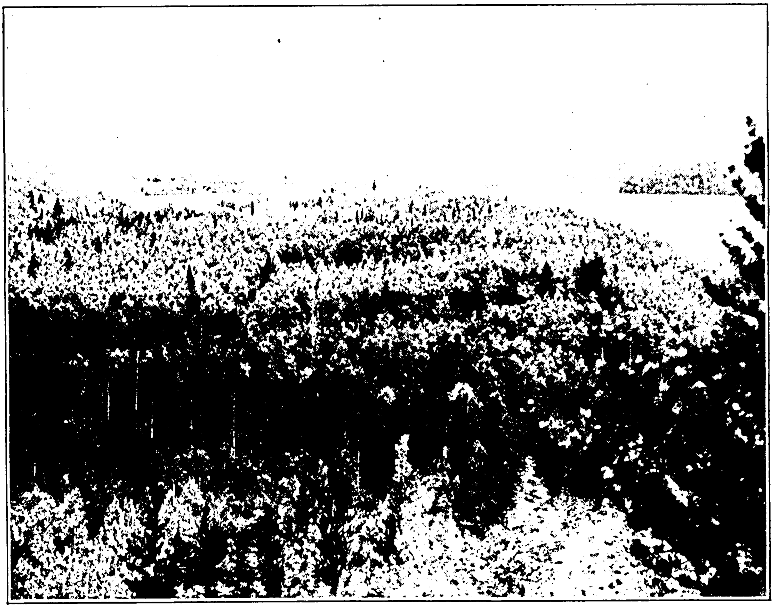

Fig. 2. Aspen-Paper Birch Forest, 50 Years Old, Superior National Forest
Occasional trees of jack pine, white spruce, and white pine in mixture.

ings could be acquired. Such areas would contain little merchantable forest now, but would serve primarily as a source of future supply.

It has been estimated that there are about 29,000,000 cords of aspen in trees 4 inches and more in diameter in the Lake States. A large proportion of this, however, is in trees 5 and 6 inches in diameter and progressively less in the larger sizes. At present most users of aspen do not utilize trees less than 6 inches in diameter. If an attempt were made to estimate the total amount of aspen in trees more than 6 inches in diameter, it would probably not exceed 12,000,000 cords.

The diameter classes from 0 to 3 inches, from 3 to 6, and more than 6 inches correspond to age classes from 0 to 25 years, 25 to 50, and 50 years and older. Aspen ordinarily reaches merchantable size in 50 years. The prediction can be made, therefore, that, altho there is less than 6 per cent of the aspen area in merchantable stands now, there will be from 15 to 40 per cent of the area that will become merchantable within 25 years, and the remaining 60 to 85 per cent will become merchantable in from 25 to 50 years. Not more than 20 per cent may die before reaching merchantable size. If the very conservative figure of 7 cords to the acre as an average stand, is used, it appears that the volume of aspen in 25 years will be 25,000,000 to 30,000,000 cords, and within 50 years more than 100,000,000 cords. These are very rough figures and make no allowances for cutting or decay, but they indicate how the present young stands will contribute to the volume that will be available in the future.

Diameters and heights attained.—The sizes of aspen at different ages vary with soil and site conditions; and the diameters, in particular, vary with the density of the stands. The average diameters that are attained in well-stocked stands in 40, 50, and 60 years on good, medium, and poor sites, are given in Table I. If 6 inches is considered to be the smallest average diameter at which aspen stands are merchantable, the figures indicate that, on sites of medium quality, the trees reach this average size in about 50 years; on good sites by 45 years; and on poor sites, not until after 60 years. If aspen is left to grow to old age, some trees may attain diameters of 12 to 15 inches and heights of 90 to 100 feet. Occasional trees are found with diameters as large as 20 inches.

TABLE I

AVERAGE DIAMETERS OF ASPEN IN WELL-STOCKED STANDS AT DIFFERENT AGES AND ON DIFFERENT SITES

Age	Average diameter breast high on		
	Good sites	Medium sites	Poor sites
Years	Inches	Inches	Inches
40	5.4	4.5	3.5
50	7.1	5.9	4.6
60	8.9	7.6	5.8

TABLE II

VOLUMES, IN CORDS, OF INDIVIDUAL ASPEN TREES, CORRESPONDING TO VARIOUS DIAMETERS AND HEIGHTS*

Diameter, breast high	Total height of tree, feet														Number of cubic feet of wood per cord†
	30	35	40	45	50	55	60	65	70	75	80	85	90	95	
Inches	Peeled volume ‡, cords														
4	.010	.013	.016	.019	.022	.026	.028	.032							58
5	.021	.025	.028	.035	.040	.045	.050	.055	.060						61
6	.034	.039	.045	.053	.060	.066	.073	.081	.088	.095					64
7			.062	.070	.079	.087	.096	.110	.110	.120	.13				68
8			.078	.089	.099	.110	.120	.130	.140	.150	.16	.17			71
9					.120	.130	.140	.160	.170	.180	.20	.21			74
10					.140	.160	.170	.190	.210	.220	.24	.26	.27		76
11						.190	.210	.230	.250	.260	.28	.30	.32		78
12							.240	.260	.280	.310	.33	.35	.37		79
13								.300	.330	.350	.38	.40	.43	.45	80
14									.370	.400	.43	.46	.48	.51	82
15									.420	.450	.48	.51	.54	.57	84
16									.470	.510	.54	.58	.61	.65	85

* Basis, 477 trees. Block indicates extent of original data.

† Standard cords, 4 by 4 by 8 feet.

‡ Volume of peeled stem above a one-foot stump to a top diameter inside of bark of 3 inches. Compiled from the merchantable volume in cubic feet by dividing the volume per tree by the number of cubic feet per cord for each diameter. Eleven stacks of closely piled wood were measured to establish the relation between cubic feet and cords. Wood was cut and piled in 8-foot lengths.

TABLE III

VOLUME TABLE BY INTERNATIONAL LOG RULE* FOR SECOND-GROWTH ASPEN†

Diameter, breast high	Number of 16-foot logs								Basis
	1	1½	2	2½	3	3½	4	4½	
Inches	Volume ‡, board feet								Trees
6	15	20	26	31	......	......	......	......	43
7	15	24	32	40	......	......	......	......	42
8	15	27	39	50	60	......	......	......	47
9	15	30	44	58	71	90	......	......	37
10	......	34	51	68	83	104	122	......	36
11	......	37	58	79	100	120	144	167	22
12	......	41	66	92	118	144	171	198	26
13	......	......	75	103	138	170	202	233	23
14	......	......	85	123	161	199	237	274	18
15	......	......	......	142	183	230	276	319	5
16	......	......	......	163	213	264	319	369	......
Basis	36	36	32	35	44	39	68	9	299

* Based on a ⅛-inch kerf.

† Block indicates extent of original data.

‡ Stump height, 1 foot; top diameter inside of bark, 5 inches; trees scaled in 16-foot lengths. Compiled by the frustum form factor method.

TABLE IV

VOLUME TABLE BY SCRIBNER DECIMAL C LOG RULE FOR SECOND-GROWTH ASPEN*

Diameter, breast high	Number of 16-foot logs								Basis
	1	1½	2	2½	3	3½	4	4½	
Inches	Volume †, board feet								Trees
7	2	3	4	6	......	......	......	......	20
8	2	3	4	6	7	......	......	......	47
9	2	3	5	6	8	9	......	......	37
10	......	3	5	7	8	10	12	......	36
11	......	4	6	7	9	11	13	15	22
12	......	4	6	8	10	13	15	17	26
13	......	......	7	9	12	14	17	20	23
14	......	......	8	11	14	16	19	23	18
15	......	......	......	12	15	19	22	26	5
16	......	......	......	14	17	22	26	30	......
Basis	22	31	27	45	25	45	35	1	234

* Block indicates extent of original data.

† Stump height, 1 foot; top diameter inside of bark, 6 inches. Scaled in 16-foot lengths. Compiled by the frustum-form factor method from data collected in 1925.

The volumes of individual trees corresponding to different diameters and heights, in terms of a standard cord, are given in Table II. The volumes of trees in board feet by the international log rule, which approximates the volume obtained by careful sawing and close utilization to 5 inches inside bark diameter at the top, are given in Table III. The volumes in board feet by the Scribner Decimal C rule, with utilization to 6 inches top diameter inside bark, are given in Table IV.

Tables II, III, and IV can be used in estimating aspen stands by multiplying the volume given for cords or board feet, as desired, by the number of trees in the tally of corresponding diameters and heights. The figure for each diameter and height is an average and may not give the exact volume for an individual tree of that size, but when applied to about 25 or several hundred trees, such as are included in a cruise tally, it should represent closely the average volume of the trees of those dimensions.

Growth and yield of aspen.—Aspen grows rapidly; in fact, it is one of the most rapid growing species in the Lake States for the first 50 years, or until the age at which it reaches merchantable size. The rate of growth varies, however, with the soil and site conditions, and with the age of the stand. For example, on a medium site at 30 years, well-stocked stands grow at the rate of about 4/10 of a cord per acre annually, and at 50 years almost 9/10 of a cord, after which the average annual growth diminishes. On a good site at 50 years, the growth rate may be as much as 1¼ cords per acre annually, and on a poor site as little as 1/10 of a cord. These figures must, of course, be reduced to allow for defect and for openings in the stands, which always decrease the yields per acre over large areas.

TABLE V

CORDWOOD YIELD FOR WELL-STOCKED ASPEN IN TREES FOUR INCHES AND OVER IN DIAMETER, BREAST HIGH

Kind of site	Age	Average total height of dominant trees	Average diameter, breast high	Basal area per acre	Peeled volume per acre*
	Years	Feet	Inches	Square feet	Cords†
Good	20	40	2.9	83	5
	30	51	4.2	102	25
	40	62	5.4	120	43
	50	70	7.0	133	55
	60	76	9.0	144	63
	70	82	10.9	151	67
	80	86	12.6	155	69
Medium	30	44	3.5	94	12
	40	53	4.5	110	30
	50	60	5.9	122	44
	60	66	7.6	133	51
	70	70	9.3	139	55
	80	74	10.6	143	57
Poor	40	44	3.5	88	11
	50	50	4.6	98	26
	60	55	5.8	105	33
	70	59	7.1	109	37

* Stump height, 1 foot; top diameter inside of bark, 3 inches.

† Standard cord, 4 by 4 by 8 feet. Close piling. Volumes in cords were obtained by applying the factors used for conversion of merchantable volumes in cubic feet to cords to corresponding average diameters at breast height. As a check, the same results were obtained from curved distributions of stems of different sizes per acre for a given age. These latter curves were also used for obtaining volumes in cords for stands with average diameter less than 4 inches.

The yields of well-stocked stands of aspen at different ages and on good, medium, and poor sites, in board feet by the International and Scribner Decimal C rules, and in cords are given in Tables V, VI, and VII. (See also Figs. 3 and 4.)

TABLE VI

YIELD OF SECOND-GROWTH ASPEN IN TREES SIX INCHES AND OVER, INTERNATIONAL LOG RULE*

Kind of site	Age	Trees per acre, 6 inches and over	Average height	Average diameter, breast high	Basal area per acre, 6 inches and over	Volume per acre†
	Years	No.	Feet	Inches	Square feet	Board feet
Good	30	170	63	6.0	33	3,800
	40	319	66	6.7	80	9,200
	50	403	70	7.6	124	16,700
	60	320	76	9.0	143	23,700
	70	235	82	10.9	151	30,100
	80	180	86	12.6	155	34,800
Medium	30	80	59	6.1	14	1,400
	40	215	60	6.3	45	5,000
	50	358	62	6.9	96	10,700
	60	378	66	7.9	127	16,500
	70	290	70	9.3	138	21,300
	80	234	74	10.6	143	24,800
Poor	40	74	53	6.1	13	1,400
	50	200	54	6.4	42	4,500
	60	306	55	7.0	81	8,200
	70	327	59	7.6	102	11,500

* Based on a ⅛-inch kerf.

† Stump height, 1 foot; top diameter inside of bark, 5 inches. Bark is not included in volume.

TABLE VII

YIELD OF SECOND-GROWTH ASPEN, TREES SEVEN INCHES AND OVER, SCRIBNER DECIMAL C LOG RULE

Kind of site	Age	Trees per acre 7 inches and more	Average height	Average diameter, breast high	Basal area per acre	Volume per acre*
	Years	No.	Feet	Inches	Square feet	Board feet
Good	30	35	69	7.3	10	500
	40	167	70	7.6	52	3,400
	50	297	72	8.1	103	9,600
	60	290	77	9.3	135	17,300
	70	235	82	10.9	150	23,600
	80	180	86	12.6	154	27,400
Medium	40	68	65	7.5	21	1,000
	50	213	66	7.7	69	4,300
	60	300	68	8.3	112	10,300
	70	268	71	9.5	132	16,400
	80	229	74	10.6	140	19,700
Poor	50	68	58	7.4	20	1,000
	60	174	59	7.6	55	3,200
	70	240	60	8.0	84	6,600

* Stump height, 1 foot; top diameter inside bark, 6 inches. Bark is not included in volume.

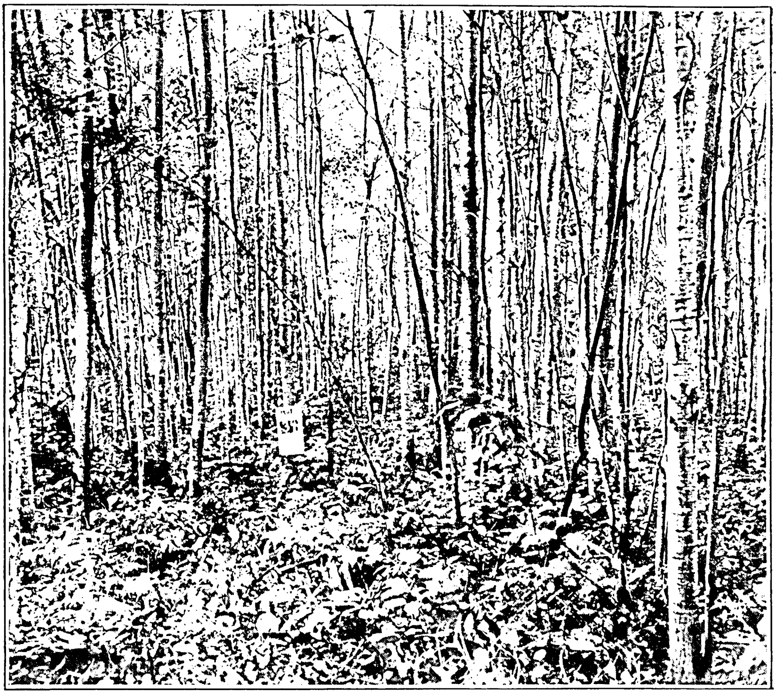

Fig. 3. Well-stocked aspen, 20 Years Old, on Good Site, Chippewa National Forest, Minnesota

If an average diameter of 6 inches is again taken as the merchantable limit, Tables V, VI, and VII show that well-stocked aspen on medium sites at 50 years will produce 44 cords to the acre in trees 4 inches and over, on good sites about 50 cords in 45 years, and on poor sites not more than 33 cords in 60 years. In board feet by the International rule, the corresponding figures are 10,000 board feet per acre at 50 years on the medium site; 13,000, at 45 years on the good site; and 8,000, at 60 years on the poor site.

The number of trees per acre from which these yields are obtained are also indicated in the tables. It is, of course, possible to obtain reasonably good yields at younger ages where the number of trees of merchantable size is correspondingly less. At 50 years on the medium site, when the trees average about 6 inches in diameter, only 358 out of 645 trees on the acre were 6 inches and more in diameter. The table for cordwood yield gives the number of trees over 4 inches in diameter, and the one for board feet by the Scribner rule, the number over 7 inches.

Over an area of 40 acres or more, there will be openings where the trees do not stand so thick and uniform as they did in the stands from

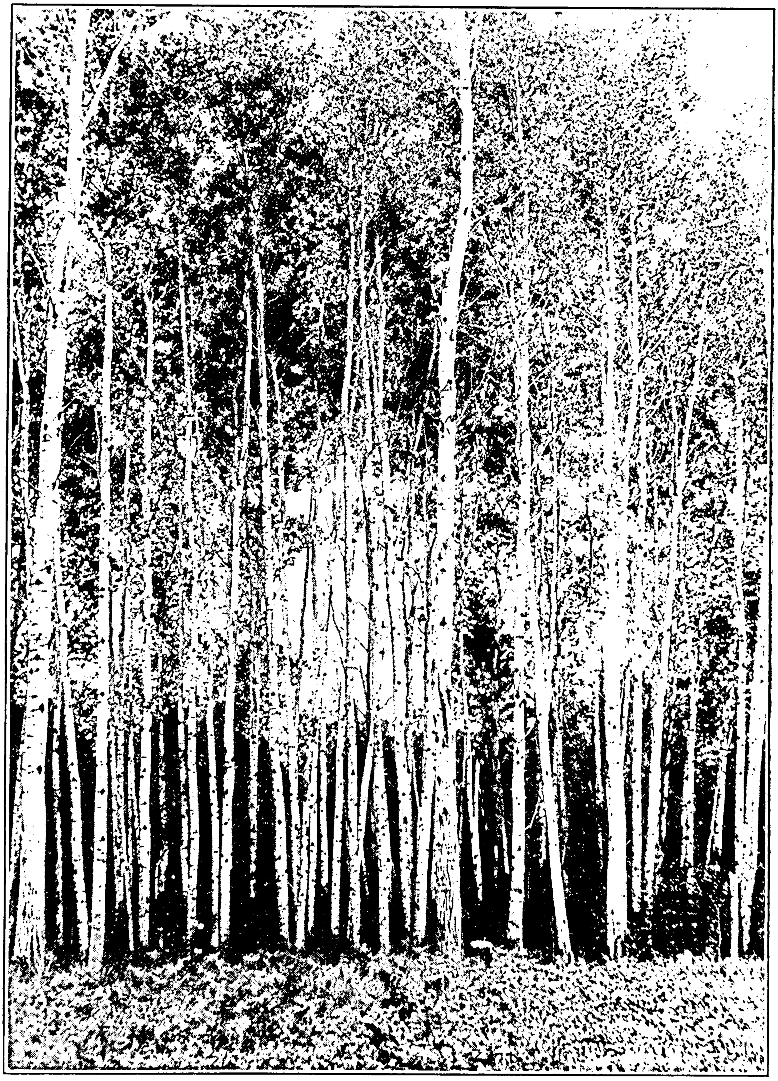

Fig. 4. Well-Stocked Aspen, Superior National Forest, St. Louis County, Minnesota

which these tables were made (Fig. 5). A cruise or estimate will indicate how much the volume per acre of any specific area falls below that given in the yield tables. A few figures from surveys of large areas will indicate how the stands may vary. A township in northern Minnesota had 11,006 acres which averaged 4½ cords to the acre; 32,000 acres in Bayfield County, Wisconsin, averaged 9½ cords per acre; 28,000 acres of aspen type on the Chippewa National Forest averaged 11 cords per acre; 1,223 acres in Bayfield County had a stand of 17 cords per acre, including the trees 3 inches and more in diameter. It is evident that aspen stands over large areas have less than half the yields indicated by the tables. It is estimated that more than two thirds of the aspen area is not well stocked and will produce smaller yields than indicated in Tables V, VI, and VII.

Fig. 5. Open Stand of Aspen, 45 Years Old, 8-Inch Average Diameter, St. Louis, County, Minnesota

Allowance must also be made in most cases for the defect caused by the fungous disease common in aspen stands. On an average site the decay caused by this disease at 40 years amounts to 7.8 per cent of the volume, at 50 years, 11.4 per cent; at 60 years, 15.7 per cent; and at 70 years, 20.5 per cent. The yield-table figures should be reduced accordingly to obtain the yields of sound wood, unless it is known definitely on a specific area whether the decay is more or less serious than that indicated by these percentages.

Ages of trees at maturity and rotation.—The average annual growth of aspen reaches a maximum at about 50 years. From then on the rate of growth decreases and the decay increases. It is therefore unwise to hold the stands to older ages if they will produce good merchantable yields at 50 years. Large yields of pulp wood on the medium and good sites will ordinarily be produced in 50 to 60 years, but large yields of saw timber, such as may be cut from stands 70 years old, are likely to be obtained only on sites better than medium. From 15 to 20 per cent of the aspen area in the northern part of the Lake States is on poor sites from which a satisfactory yield of merchantable aspen will rarely be obtained.

Diseases of aspen.—Aspen is highly susceptible to a number of diseases. These may be grouped as: (1) those affecting the leaves; (2) those affecting the twigs, branches, and the trunk; and (3) those attacking the wood of standing trees.

One of the most common and widespread leaf diseases of aspen is caused by *Sclerotium bifrons* E. and E. The disease is characterized by the eventual death of the entire leaf. Under certain conditions, as much as one half of the entire foliage of a tree may be killed. The dead leaves are usually persistent until autumn. The disease is very common in the southwestern stats, and has also been reported as occurring in the northern Rocky Mountain region, New England, the Adirondacks, and Wisconsin. Altho no detailed study seems to have been made of the effect of this disease on the rate of growth of aspen, it must be appreciable if the infection is heavy.

Another common and important leaf disease of aspen is caused by a fungus usually referred to as *Marsonia populi* (Lib.) Sacc. This disease is reported as the cause of a blight in the Rocky Mountain region from Colorado to Idaho. It also occurs in New England and in the Lake States, but apparently is seldom the cause of great damage.

The young shoots of aspen are often affected by a disease that causes them to turn almost a jet black and to bend back. The petioles of leaves attached to such twigs also become blackened and portions of the leaves may be similarly affected. The disease is believed to be caused by the fungus *Napicladium tremulae* (Frank) Sacc. It is not yet certain, however, that a somewhat similar condition may not be caused by other organisms. The disease is widespread and occurs practically throughout the range of aspen.

At least four fungi are known to cause cankers of the branches and the main trunk of aspen. Two of these are of European origin, and one of the two is known to occur in the United States.

By far the most common canker of aspen in the Lake States region is caused by *Cytospora chrysosperma* (Pers.) Fr. Cankers caused by this fungus are characterized by the reddish yellow spore horns which give them a bewhiskered appearance when the spores are produced.

Another important canker of aspen in the Lake States is caused by *Hypoxylon pruinatum* (Klotsche) Cke. Cankers caused by this fungus are usually confined to the trunk, and eventually kill the tree by girdling it. As it has not been reported on trees more than 6 inches in diameter, this disease would seem to be confined to comparatively young trees.

A study[2] of *Hypoxylon* canker in the Lake States showed 37 per cent of the trees on sample plots infectd, and 37 per cent killed by the disease. How prevalent this type of canker is in the Lake States region is not known.

A canker occurring on aspen is of importance, irrespective of the specific cause, as it may eventually lead to the death of the tree or be the means of entry for wood-destroying fungi.

By far the most important group of diseases affecting the utilization of aspen are those that cause the wood of standing trees to decay. Altho a large number of wood-destroying fungi have been reported as occasionally occurring on aspen, two fungi, the false tinder fungus (*Fomes igniarius*) and the butt-rot fungus (*Fomes applanatus*) account for practically all of the rot ordinarily found in this tree.

Altho *Fomes igniarius* is the cause of a heart rot and *Fomes applanatus* is characteristically the cause of butt rot, it is not necessary to consider separately the losses caused by them. For all practical purposes there is no important difference in their effects on the chemical and physical properties of aspen wood.

Three stages of decay are arbitrarily distinguished: (1) incipient, (2) intermediate, and (3) final. The incipient stage of decay is of little importance, as it is seldom recognized and never culled by any industry using aspen. The intermediate stage includes all variation in color from straw to chocolate brown, but the wood is apparently still hard and firm. This stage of decay is recognized as a defect in aspen lumber, but for many uses the utility of the wood is not seriously impaired. The final stage of decay includes all soft, punky wood, irrespective of color. This stage of decay is considered as a serious defect and is culled by all industries using aspen.

At 70 years of age, the total rot, namely, incipient, intermediate, and final, affects 31.2 per cent of the merchantable volume of the tree; at 60 years, 27.5; at 50 years, 23.0; at 40 years, 18.9; and at 30 years, 14.8 per cent. At 70 years the intermediate and final stages of decay include 20.5 per cent of the merchantable tree volume; at 60 years, 15.7; at 50 years, 11.4; at 40 years, 7.8; and at 30 years, 4.8 per cent.

The figures must not be taken too literally, and they can not be applied with exactitude to a specific area. They indicate only the proportion of decay which, on an average, might be expected in aspen in Minnesota. They also indicate the desirability, at least from the standpoint of heart rot, of growing aspen under a 40- to 50-year rotation.

The study from which the foregoing percentages were obtained

[2] Poran, A. Hypoxylon, poplar canker. Phytopath. 14:140-145. 1929.

was made in "wild" stands. Under forest management, injurious factors which have contributed to the defective condition of the present stands will undoubtedly be materially reduced. Fire is the most important of these injurious factors, because fire scars offer an excellent means of entry for wood-destroying fungi. Mechanical injuries, canker, and insects are also important causes.

Stumpage values.—The value of standing aspen depends upon many factors, including not only the amount and quality of the aspen, but its location with respect to roads, railroads, or manufacturing plants. The prices which have been paid for standing aspen during the last few years vary from 25 cents to $1 per cord and from $1 to $2 per thousand board feet. There are still many areas of aspen, however, that are so located that the owners are unable to sell them at any price. As the use and demand for aspen increases, more of the stands that at present are not salable will become marketable and the average stumpage value which may now be between 50 cents and $1 a cord will tend to increase.

Possibilities of Aspen as a Forest Crop

As a forest crop for the repeated or permanent production of wood products, aspen offers several marked advantages. It is one of the easiest trees to reproduce after cutting. It is only necessary to cut as clean as possible, and during the first two seasons, following the cutting, a dense crop of rapidly growing aspen suckers is assured. On land that produced a merchantable yield at the time of cutting, the suckers may be expected to grow and after 50 years again to provide a good yield. Often the aspen stands are extremely dense suggesting that their growth may be retarded. The larger trees forming the crop at maturity, however, seem to be only rarely seriously retarded. Thinnings might stimulate the growth somewhat in dense stands. At the ages of 15 to 30 years when the thinnings would be most beneficial they will not provide any return in the form of marketable products for the cost of making them. The possible later return induced by increased growth has not yet been demonstrated.

The most interesting and practical suggestion for those who are considering aspen as a forest crop is the possibility of acquiring areas of young growth for a future supply. It has been shown that the aspen lands in the Lake States include a large proportion of stands less than 3 inches in diameter, and from 5 to 20 years old. This young aspen is now considered to have little or no value. It is growing rapidly, however, and will produce a good yield at least of cordwood products when it is 40 to 50 years old. The acquisition of land, with young growth already established, means, therefore, reducing the period, during which the land must be held and taxes paid, by a number of years corresponding to the present age of the young growth. The cost of holding land for a forest crop 20 years, as compared with 40 or 50 years, obviously is much less. The fire hazard in holding the young stands is not so great as would be that on freshly cut-over areas, and in case of destruction by fire, only the growth for the period corresponding to the age of the young stand is lost.

Altho aspen grows on some excellent agricultural soils, there are also large areas on rough or stony soils that have little or no value at present, as indicated by the large areas of land of this type that are added to the tax-delinquent rôles each year. In the following calculations, the aspen lands have been given a value of $2 an acre, altho many areas of aspen could not be sold at that price. Any reduction of the land value would increase the figures of profit given below. The expenses of holding aspen lands have been placed at 10 cents an acre a year—the figure adopted in the Wisconsin forest tax law—with an additional 3 cents per acre per year for special protection by the owner aside from that provided by the state. With these assumptions, figures of the interest returns from growing aspen crops for different combinations of yield per acre, growing period, and stumpage values after a 10 per cent yield tax has been deducted, are presented in Table VIII.

TABLE VIII

COMPOUND INTEREST EARNED ON INVESTMENTS AND COSTS OF GROWING ASPEN IN RELATION TO YIELDS AND STUMPAGE VALUE*

Growing period	Yield per acre	Stumpage value per cord less 10 per cent yield tax				
		$0.45	$0.90	$1.35	$1.80	$2.25
Years	Cords	Compound interest rate				
30	5	loss	0.3	1.9	3.0	3.9
30	10	0.2	2.9	4.5	5.6	6.5
30	20	3.0	5.6	7.1	8.2	9.1
30	30	4.5	7.1	8.7	9.8	10.7
40	5	loss	loss	0.7	1.6	2.3
40	10	loss	1.6	2.8	3.7	4.3
40	20	1.6	3.7	4.9	5.8	6.4
40	30	2.8	4.9	6.1	7.0	7.7
50	10	loss	0.9	1.9	2.6	3.1
50	20	0.9	2.6	3.6	4.2	4.8
50	30	1.9	3.6	4.6	5.3	5.8
50	40	2.5	4.2	5.2	6.0	6.5

* Land value, $2 an acre; annual expense, 10 cents for taxes plus 3 cents for protection.

Table VIII can be used in several ways. The increased profitableness of selecting and holding aspen lands that are accessible and, therefore, have higher stumpage values, but that have good stands that will produce high yields is obvious. For example, an area so located that its stumpage will be worth $2 a cord and that will produce 20 cords to the acre after 30 years, will yield more than 8 per cent interest, whereas one on which the stumpage value is only 50 cents a cord and that will produce only 10 cords to the acre will yield only two tenths of 1 per cent interest. The higher yield results, of course, on areas of good site quality and where the trees stand thickly. These points have been brought out in the discussion of growth and yield. A further advantage appears in the reduction of the length of the growing period, an advantage inherent in a good site quality and one that may also be obtained by acquiring at low prices aspen which is already 10 or 20 years old, and by that number of years nearer to merchantable size. In Table VIII, if a yield of 20 cords to the acre and a stumpage value of $1 a cord are assumed, a stand which can be cut in 30 years will earn 5.6 per cent interest, whereas one which must be held for 50 years will earn only 2.6 per cent interest. Another use of the table can be made by anyone who wishes to set the interest which his aspen lands must produce, and on that basis decide what kinds of land and stands he will buy or hold. If he estimates that aspen will be worth $1.50 a cord (equivalent to $1.35 as shown in column 5, Table VIII) and 5 per cent is the minimum rate of interest that he is willing to accept, the table indicates that the aspen stands must yield at least 12 cords in 30 years or 21 cords in 40 years, or 37 cords if it is necessary to hold them for 50 years. Looking at it in another way, if it appears that a yield of only 10 cords to the acre can be obtained, then to earn 5 per cent, the stumpage value after 30 years must be about $1.75 per cord, and after 40 years, more than $2.50 per cord.

In general, considering the large proportion of well-stocked aspen stands already 10 to 20 years old which may be expected to produce 20 cords to the acre when they are merchantable, interest rates earned by the growth of such stands, even at present stumpage values, are mostly above 4 per cent.

Further Information Needed

Further information needed may be summarized as follows:

1. At what ages on different qualities of site, and especially on the poor qualities, does aspen deteriorate and the stands die before reaching merchantable size?

2. Are there any means by which the decay in aspen from the prevalent fungous disease can be prevented or minimized in a practicable way?

3. The collection of information currently by the census or other agency on the stumpage values of aspen separately from those of cot-

tonwood, poplar, or other species, should be undertaken and included in published reports.

4. Better and more complete information is needed as to the locations, age classes, site qualities, and stands per acre of aspen in the region. Some of this information is being obtained in certain counties by the state land economic surveys. Their work should be encouraged, and expanded and supplemented to provide more nearly complete information.

PROPERTIES[2]

General Relation of Properties to Use of Wood

The clear wood of aspen has inherent properties of merit. Several of these properties are familiar to a large proportion of the general public, for some of the common types of matches are made of this wood. The requirements of wood for matches are exacting in that the wood must combine straightness of grain, ease of splitting, ease of working, and toughness. To meet such rigid requirements, a wood must be suitable for other uses as well. The fact that aspen is not used more widely for other purposes lies not in the wood itself but in other factors, such as cost, distribution of stand, and availability in desired sizes and grades. Cost, demand, and harvesting and marketing practices change as conditions change. The fact that in the past some of these factors have been adverse to the utilization of aspen stands does not mean that the wood can not be used more widely now and in the future at a reasonable cost and without sacrifice of the quality of the product.

The utilization of the existing stands of aspen has been retarded because the lumber-buying public is not generally familiar with the properties of the wood. There has been little incentive to inform consumers of the properties of a wood which was but little used. There has been a very general tendency to underrate all of the properties of aspen. Other species, such as cottonwood, eastern hemlock, and red gum, have passed through a similar stage. A comparison of the properties of aspen with those of other well-known woods will correct some of the existing erroneous ideas and should aid in the better utilization of the species.

The other woods with which aspen is compared are those that are used for many of the same purposes. In addition, comparison is made with a few of the best known species of the Lake States. The comparisons are made in Table IX by using aspen as 100 points. The other woods are shown as so many points above or below aspen.

[2] This section under the general heading "Properties," that deals with the mechanical properties and characteristics of the wood and the grading of the lumber, was written by R. P. A. Johnson, engineer, Forest Products Laboratory, Madison, Wisconsin.

TABLE IX

Average Mechanical and Physical Properties of Clear Wood of Aspen Compared with Other Species*

Species	Weight per cubic foot: Green (1)	Weight per cubic foot: At 12 per cent moisture content (2)	Shrinkage (3)	Bending strength (4)	Compressive strength (endwise) (5)	Stiffness (6)	Hardness (7)	Shock resistance (8)	Nail holding power (9)	Splitting resistance (10)
	Pounds	Pounds	Points	Points	Points	Points	Points	Points	Points	Points
Aspen†	43	27	100	100	100	100	100	100	100	100
Largetooth aspen†	43	27	105	105	119	121	123	94	105	131
Basswood	41	26	142	97	107	118	100	81	101	118
Eastern cottonwood†	49	28	124	98	110	115	116	109	99	169
Balsam poplar†	40	23	94	76	83	89	81	64	-	96
Yellow poplar	38	28	107	113	117	126	129	87	112	171
Northern white cedar	28	22	62	79	90	73	97	70	80	93
Balsam fir	45	26	93	94	116	110	100	75	-	76
Eastern hemlock	50	28	88	114	136	113	165	100	117	88
Jack pino	50	30	92	102	126	104	155	116	129	127
Northern white pine	36	25	75	100	116	111	113	82	114	98
Eastern spruce‡ (commercial)	34	28	113	111	129	121	126	101	113	100

* This table is for use in comparing the clear wood of aspen with that of other species, or for comparing aspen lumber with lumber of other species containing like defects.

† Sometimes sold mixed with aspen under the commercial name of popple.

‡ Average red and white spruce.

Physical Properties

Structure, color, and odor of aspen wood.—Aspen has an exceedingly fine and uniform texture. The pores are not visible to the unaided eye on smooth-cut end surfaces and the annual growth rings are visible only upon close inspection. The result is a wood of uniform surface with practically no distinct markings. Finshed, it has a silky luster.

The wood resembles that of large-tooth aspen so closely, both in general appearance and cellular structure, that they can not be distinguished from one another. In structure, it also closely resembles that of various species of cottonwood. It can, however, usually be distinguished from them by the larger pores of the cottonwood, which are visible to the eye on a smooth-cut end surface.

As a rule the wood of aspen, both heartwood and sapwood, is practically white. On exposure to light and air the surface becomes a pale brown or pinkish brown. The inner part of aspen logs is frequently discolored by decay. In the early stages of decay, the infected part may be mistaken for heartwood. The wood around the knots is also colored brown, which contrasts strongly with the white wood and, at a casual glance, makes the knots appear much larger than they are (Fig. 6). The source of the dark color is unknown. It has been ascribed to action of wood-destroying fungi. Microscopical examination of some of the dark colored wood, however, failed to reveal any sign of fungous action.

The cottonwoods, balsam poplar, and basswood are other light-colored woods with which aspen is occasionally confused. The cottonwoods and balsam poplar, however, have a pale gray or grayish brown heartwood, whereas that of aspen is white. Basswood is distinguished from aspen by the finer structural differences rather than by color. Aspen lumber when surfaced, however, has a characteristic silky lustre that is more pronounced than in any of the foregoing woods.

There exists a decided preference for light-colored or white woods for a number of uses; the reasons for which are sometimes difficult to understand, as in the case with matches and ladders. If markings and stencils are to be used, the whiteness has a utility value. Other users prefer white wood because of appearance. Butter boxes and comb-honey containers are uses in which the clean appearance of a white wood is desirable.

Aspen has only a slight odor, like that in the cottonwoods and balsam poplar, noticeable in shops when the wood is worked. Because the wood has little if any tendency to impart odor to foodstuffs, it is used for butter boxes, egg crates, and excelsior. The odor of basswood, tho not strong, is distinctly different from that of aspen and helps in distinguishing the two woods.

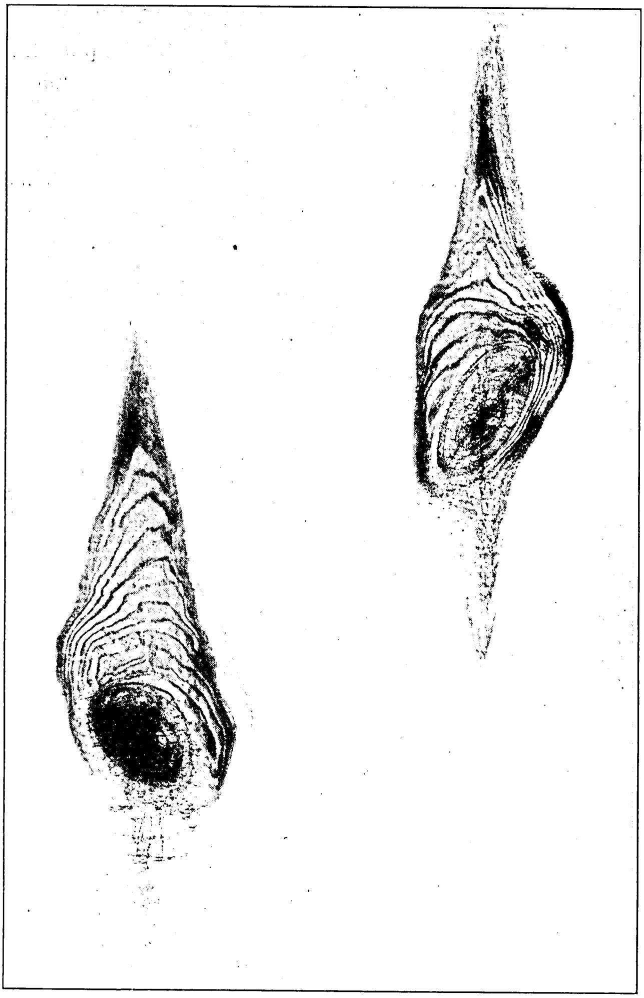

Fig. 6. The Knots in Aspen Are Characteristic of the Species. No Trace of Decay Was Found in Microscopical Examinations of the Dark-colored Wood Surrounding the Knots

Weight per cubic foot (green and air-dry).—Aspen is one of the hardwoods of light weight. In a thoroly air-dry condition (12 per cent moisture content in the Lake States) aspen weighs on the average, 27 pounds per cubic foot. One thousand board feet of nominal 1-inch dry aspen lumber surfaced to a thickness of 25/32 inch would weigh about 1,760 pounds. Similar amounts of other woods would weigh: basswood about 1,690 pounds, eastern cottonwood 1,830 pounds, sugar (hard) maple, about 2,870 pounds. A comparison of the weight of air-dry aspen with other species, all valued for their lightness, is shown in Figure 7.

Generally the lighter the weight of the dry wood the weaker and softer it is. Like all general rules, this one has some exceptions. Thus, altho yellow poplar is heavier and harder than aspen, aspen is higher in shock resistance. Large-tooth aspen and aspen weigh the same, but large-tooth aspen is harder and tests higher in all strength properties except shock resistance or toughness (Table IX). Such exceptions usually occur where differences in weight are small. Where differences in weight are large, as between maple and aspen, the general rule holds true.

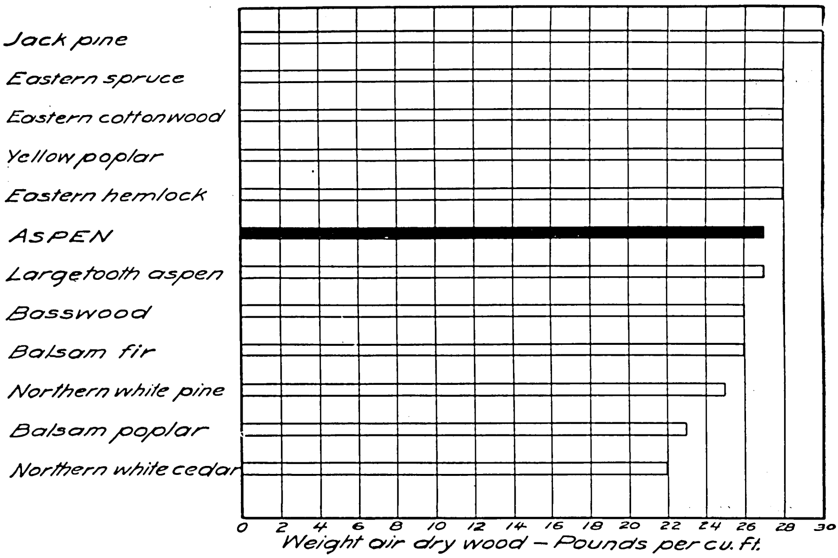

Fig. 7. Weight of Air-dry Aspen, 12 per Cent Moisture Content, Compared with the Weight of Several Other Species

The light weight of aspen is obviously an asset or a liability, depending upon the use to which the wood is put. Lightness is an asset in boxes, pails, and other containers because it reduces the cost of transportation. Likewise, wood of light weight is preferred for spools and for excelsior. Ladders made of lightweight wood are easier to handle than those made of heavy woods. Woods of light weight are also preferred for toys for small children. The tare or dead weight of vehicle body parts may be lessened by the use of lightweight woods. For flooring, stringers, butcher blocks, and similar uses, woods that are heavier and harder than aspen are preferred. Aspen is best adapted to uses where lightness is more important than strength and where a combination of strength and lightness is desired.

Shrinking and swelling.—Small shrinkage is one of the favorable properties of aspen. Changes of dimension with changes in atmospheric conditions are the source of many troubles encountered in the use of wood. The objections to changes in size of interior trim, doors, windows, staves, and ready-cut stock are well known.

The shrinkage and swelling of aspen with moisture changes is less than that of basswood, eastern cottonwood, or yellow poplar, woods favored by manufacturers of articles with small srinkage requirements. Northern white pine and northern white cedar, woods widely known for their small amount of shrinkage, shrink less than aspen. The difference between these species and aspen, however, is less than the difference between aspen and basswood.

Fig. 8. Comparison of the Average Shrinkage of Aspen with Several Other Species
Aspen has a low shrinkage and consequently will not expand or contract much with slight changes in moisture content.

Comparisons of the shrinkage of aspen with that of several other species are shown in Figure 8, which is based on the total shrinkage from a green to an oven-dry condition. The relative change in dimension that may be expected with different species in service with any given change in atmospheric or moisture conditions may be observed in Figure 8.

Trouble from changing dimension in service is more often caused by the use of green or insufficiently dried lumber than to the inherently high shrinkage of the species. Any advantage which aspen may have as a result of its low shrinkage may be more than lost by the use of wet lumber. The difference in the change in dimension in drying from 20 per cent and 12 per cent moisture content to 6 per cent moisture content is greater than the difference in the shrinkage of aspen and any of the species shown in Figure 8. The use of aspen or any other species, therefore, will not insure small change in dimension unless the wood is dried to approximately the average moisture content it will have in use.

Mechanical (Strength) Properties of Wood

Bending strength.—The clear wood of aspen has the same bending strength as northern white pine (Fig. 9). Northern white pine has been used for years in construction work where bending strength is important. The clear wood of eastern spruce and eastern hemlock, two species also used largely in construction, is slightly higher in bending strength than that of aspen. The bending strength of construction lumber is dependent more upon the defects present

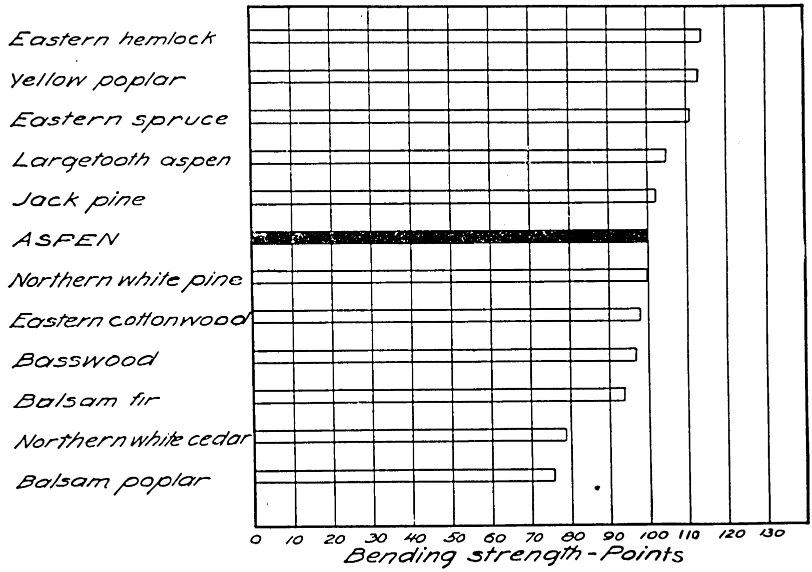

Fig. 9. Average Bending Strength of the Clear Wood of Aspen Compared with Several Other Species

The bending strength of aspen compares favorably with that of a number of important commercial species. The strength of large-sized stringers, heavy joists, and rafters depends primarily on the size, number, and location of knots and other defects.

than upon the strength of the clear wood. This along with other factors means that aspen has better prospects for industrial and fabricated uses requiring small, clear pieces than for construction uses. Brush and broom handles, toys, matches, kitchen utensils, and washboards are examples of industrial uses requiring small, clear pieces. Altho properties other than bending strength are usually of major importance in such uses, some bending strength is necessary for satisfactory service.

The use of aspen where bending strength is of first importance probably will always be limited. Aspen lumber is not generally available in the sizes and grades desired for construction work. Small amounts for construction are sometimes used locally, but the largest use of aspen timber for construction purposes is in round form for mine timbers. Even as mine timbers, the use of aspen is confined almost entirely to mines close to aspen stands. Where mine timbers must be shipped in, heavier, stronger, and more decay-resistant woods are preferred.

Compressive strength (endwise).—Aspen is used in only a few cases where high compressive strength (endwise) is desired. Compressive strength (endwise) is an important requirement of posts and short columns that are required to support heavy loads. Such structural members are usually 6 by 6 inches in cross section or larger. Practically no material of this character is produced from aspen because of the small size of the tree.

Considerable aspen is, however, used for mine timbers where compressive strength (endwise) is an important requirement. For mine timbers it is used mostly in log form. Occasionally pieces 2 by 2

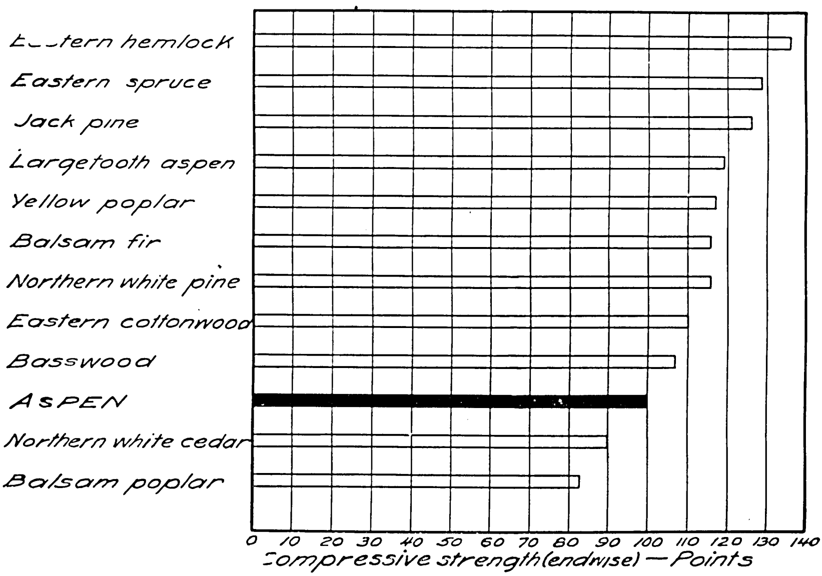

Fig. 10. Average Compressive Strength (endwise) of the Clear Wood of Aspen Compared with Several Other Species

Aspen posts and short columns have low load-carrying capacity. The strength of large-sized posts depends mostly on the size, number, and location of knots and other defects.

inches or less in cross section and 20 inches or shorter in length are required to support a heavy load. Such posts, to have an equal load-carrying capacity, should be slightly larger than cottonwood or jack pine posts, but may be somewhat smaller than balsam poplar or northern white pine (Fig. 10). Mixed lots of posts, sold as "popple," "poplar," or "cottonwood," average higher in strength than straight lots of aspen posts. This is because of the higher compressive strength (endwise) of cottonwood and large-tooth aspen.

The compressive strength of aspen is comparatively low. However, it is generally sufficient for most of the uses into which the species goes, inasmuch as in these uses properties other than compressive strength usually control.

Shock-resisting ability.—Aspen is relatively shock resistant for a lightweight wood. Basswood, yellow poplar, and northern white pine, woods noted for their softness and light weight, are lower in shock-resisting ability than aspen (Fig. 11).

Shock-resisting ability, or toughness, is dependent on the dry weight of a wood; therefore, the slightly heavier cottonwood and jack pine are somewhat more shock resistant than aspen. Very heavy hardwoods, such as ash and elm, are much higher in this property than aspen.

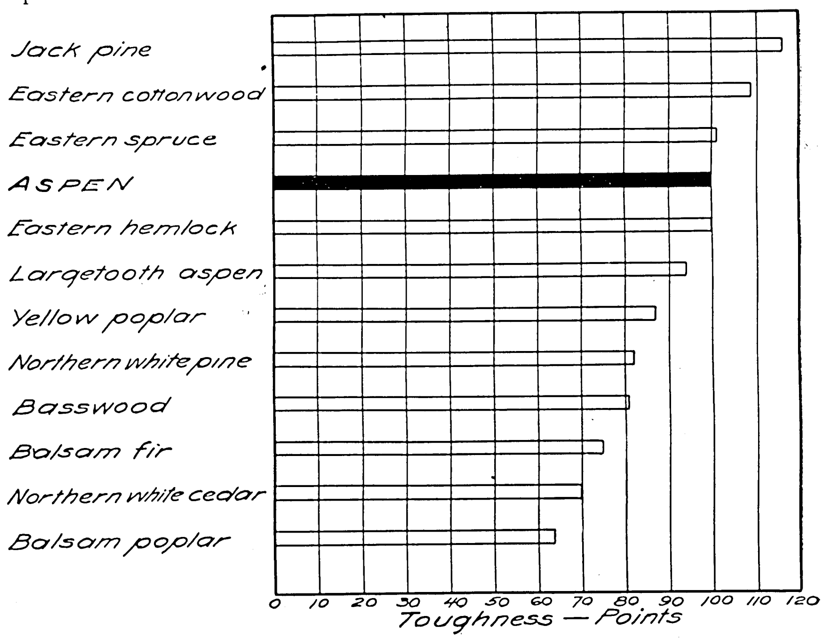

Fig. 11. A Comparison of the Average Shock-Resisting Ability or Toughness of the Clear Wood of Aspen with Several Other Species

The shock-resisting ability of aspen contributes to its successful use as canoe frames, matches, excelsior, toys, and crating.

The shock resistance possessed by aspen increases its range of usefulness. It is an asset in crating, consequently much aspen is used for this purpose, particularly in the form of barky strips. Basket hoops, canoe frames, and ladders are examples of other uses employing lightweight soft woods, where shock resistance is also a desired property. Even for small articles, such as golf tees, matches, and parts of toys, shock-resistance is an advantage. In mine timbers, either round or sawed, shock resistance is desired because tough woods give more warning of failure than brittle woods. The well-known qualities of aspen excelsior is largely due to the toughness of the wood combined with other properties desired for this material. In general, while the shock-resisting ability and other properties of aspen are not sufficient to meet the requirements for such uses as ax handles, pitchfork

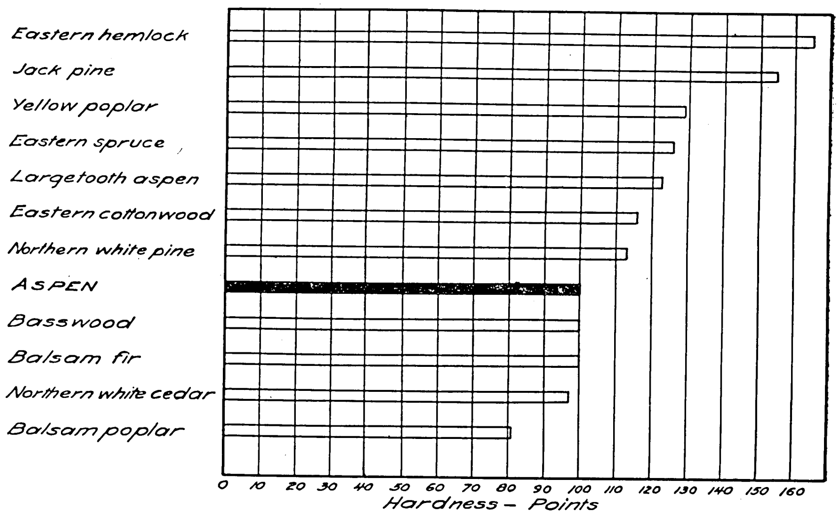

Fig. 12. Average Hardness of Aspen Compared with Several Other Species
Aspen is a soft hardwood. It is suitable for uses where softness rather than hardness is desired.

handles, baseball bats, and hockey sticks, they are sufficient to meet the requirements for the uses to which lightweight softwoods are usually put.

Hardness (or softness).—A number of woods such as aspen, northern white pine, basswood, and yellow poplar, are in demand, largely, because of their softness. Aspen, basswood, and balsam fir have about the same average softness. They are softer than northern white pine and yellow poplar (Fig. 12).

The greatest advantage of the softness of aspen is in the working of the wood. Wood for excelsior, matches, baskets, dowels, veneers, and spools must be easy to cut or shape. For some uses, such as drawing and drafting boards, softness is desired. Aspen is adapted to uses where softness is desired either in manufacture or in service.

Aspen is soft and uniform in texture, i.e., it does not have alternate bands of hard and soft wood. Such woods are easier to work than those with non-uniform texture. In this respect aspen is very similar to basswood and yellow poplar, which are preferred for a number of uses because of their softness and uniform texture. Aspen can meet requirements for a combination of uniformity of texture and softness equally as well as either yellow poplar or basswood.

Stiffness.—Aspen is not a stiff wood. It will bend more under a given load, other things being equal, than jack pine, basswood, or northern white pine, but less than balsam poplar or northern white cedar. The stiffness of aspen is compared with that of a number of

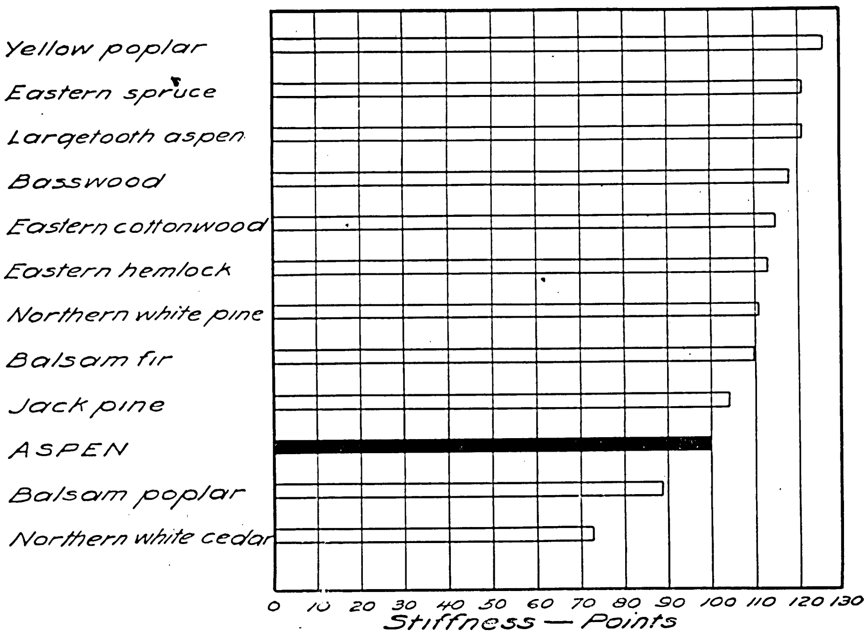

Fig. 13. A Comparison of the Average Stiffness of the Clear Wood of Aspen with Several Other Species

Aspen is not a stiff wood, but oversizes are not necessary to obtain sufficient stiffness to meet the requirements of most of the uses into which the wood goes.

other species in Figure 13. The comparisons are for clear wood but apply almost as well to wood containing knots or other defects, for defects have little if any influence on stiffness.

Stiffness is one of the important requirements of joists, studs, and other framing material. Aspen framing material would have to be somewhat larger in size than that of eastern spruce or eastern hemlock to have equal stiffness. Aspen is used for framing only in small quantities, as it is not available in as many sizes and grades as a number of the coniferous woods.

In most of the uses to which aspen is put, stiffness is not of importance. The stiffness of aspen is such that oversizes are not necessary to obtain sufficient stiffness for such uses as baskets, boxes, small handles, and beekeepers' supplies.

Nail-holding power.—The average holding power of a 7-penny cement-coated nail driven 1¼ inches into the side grain of dry aspen is 194 pounds.[3] The same sized nail driven into green aspen would have about the same holding power when first driven. The holding power would, however, decrease rapidly as the wood dried (Fig. 15). The holding power of the nails driven into green aspen is only about 20 pounds after the wood has thoroly dried.

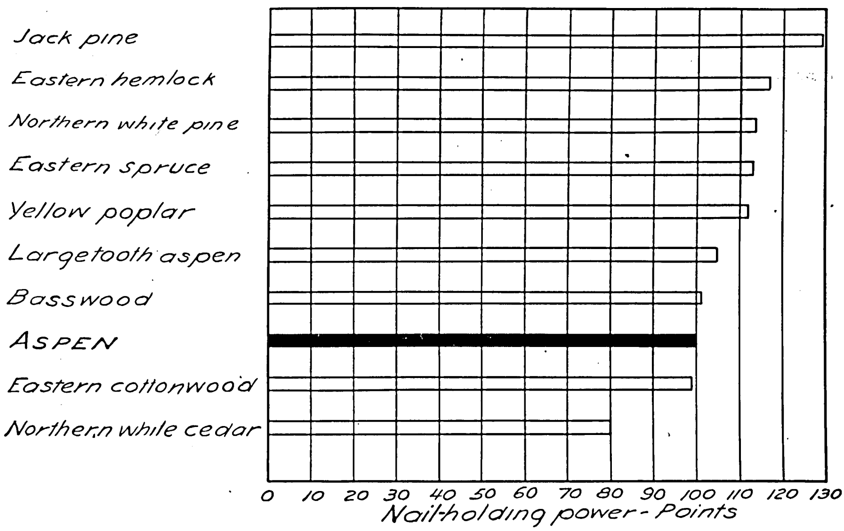

Fig. 14. The Nail-holding Power of Aspen Compared with That of Several Other Species
Aspen has about the same nail-holding power as some of the soft hardwoods of light weight, but it has somewhat less nail-holding power than white pine. In service, the small tendency of aspen to split in nailing results in little loss in holding power from this cause.

The nail-holding power of aspen is comparatively low, about the same as that of basswood and eastern cottonwood. Jack pine, eastern hemlock, and northern white pine have a higher nail-holding power than aspen (Fig. 14). More or larger nails must, therefore, be used with aspen to obtain a nail-holding power equal to that of the latter

[3] "Nail-holding Power of Various Species of Wood," by L. J. Markwardt and J. M. Gahagan, Forest Products Laboratory, published in "The Timberman," August, 1929; the "Southern Lumberman" of July 15, 1929, contains detailed data on nail-holding power of 50 species including aspen.

woods, provided they split no more than aspen in nailing. Fortunately the softness and uniform texture of aspen usually permits the use of a nail large enough to obtain the necessary nail-holding power without undue hazard from splitting. For uses, such as framing, where nail-holding power is desired to hold a covering, an increase in the size or number of nails is not generally necessary to obtain satisfactory nail-holding power. Even in standard food boxes where the nailed joints are usually the weakest parts, recent tests at the Forest Products Laboratory showed that it was not necessary to increase the size or number of nails in aspen boxes to obtain satisfactory resistance to rough handling.[4] The aspen boxes stood more rough handling than boxes of a number of species with higher nail-holding power. The smaller tendency of aspen to split at the nails was apparently sufficient to more than compensate for its lower nail-holding power.

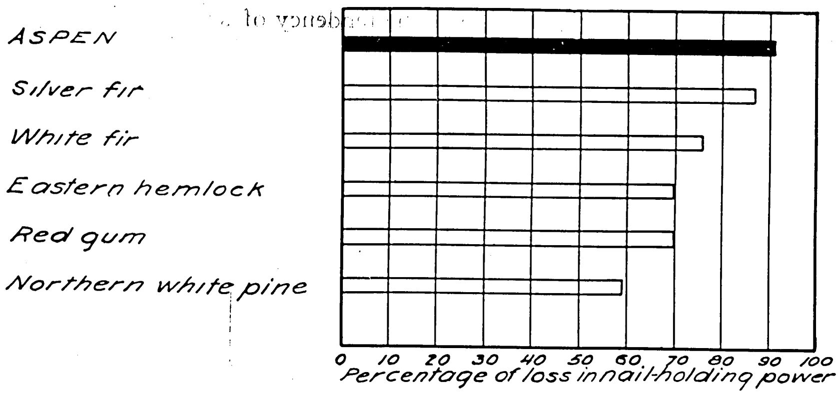

Fig. 15. The Loss of Nail-holding Power of Aspen and Several Other Woods When Nails Are Driven Into Green Wood and Pulled After Seasoning

So large is the loss in nail-holding power under these conditions, that it is poor practice to nail into the green wood of any species which will later dry in service.

Nails driven into green aspen lose about 90 per cent of their nail-holding power when the wood has thoroly dried (Fig. 15). Satisfactory service can not be expected when nails are driven into green aspen and the wood allowed to dry out later in service. It is poor practice to nail any species while in a green condition, but especially so with aspen.

Splitting.—Aspen is straight grained and consequently easy to split. In this respect it is about the same as eastern spruce. Eastern

[4] Results of these tests on boxes made of aspen and eight other woods are given in articles by T. A. Carlson, published in "Packages," 32, No. 3: 11, 14, 16, 22; March, 1929; "Packing and Shipping," 55, No. 12: 21-25, March, 1929; and "Mississippi Valley Lumberman," 60, No. 11: 26-27, March 15, 1929.

cottonwood and yellow poplar are much harder to split than aspen; balsam fir and eastern hemlock are somewhat easier (Fig. 16).

Some uses require a wood that is easy to split and others, a wood that is hard to split. Matches, toothpicks, and shoe pegs are uses that require easily split woods; uses such as vehicle body parts, where bolts are used for fastenings, require wood with high splitting resistance. Aspen is better suited to the first than to the second type of uses.

Splitting in nailing is dependent more upon the softness and texture of wood than upon the splitting resistance. The softness and uniform texture of aspen are responsible for it splitting less in nailing than many harder woods with higher splitting resistance. Washboards, brooms, and boxes require woods with little tendency to split in nailing. Aspen is well adapted to such uses because its low splitting resistance is more than offset by its softness and texture, resulting in a low tendency to split in nailing. The tendency of small or thin parts,

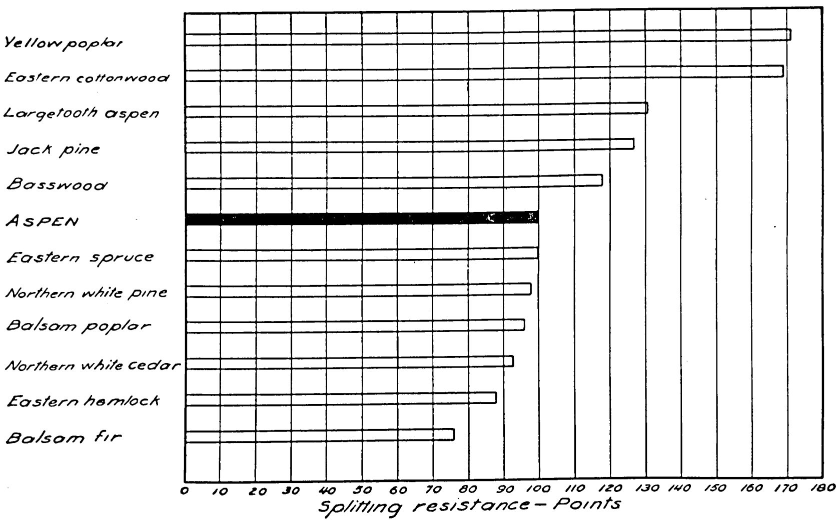

Fig. 16. Comparison of the Splitting Resistance of the Clear Wood of Aspen with That of Several Other Species

Splitting resistance is a measure of the resistance to splitting from the action of wedges and bolts but it is not a measure of the tendency to split in nailing, which is dependent largely on the hardness and texture of the wood.

such as egg case tops, sides, or bottoms, to split in nailing can be materially reduced by the use of blunt-pointed nails, but at some sacrifice in holding power. Aspen veneer or thin shooks can often be successfully nailed with blunt-pointed nails when it is impractical to reduce splitting sufficiently by reducing the size of the nail.

Decay Resistance

Aspen is classed with basswood, cottonwood, and the true firs in the matter of decay resistance. The heartwood of these species is low in decay resistance. The sapwood of all species has a low resistance to decay.

When the heartwood or sapwood of aspen is to be used for railway ties, poles, fence posts, mine timbers, or other uses where it is in contact with the ground or exposed to moist or wet conditions, it should be treated with a preservative. Furniture, brush handles, boxes, and similar articles are seldom used under conditions favorable to decay. In such uses, decay resistance is of no importance and untreated aspen will last as long as the decay-resistant woods.

The actual life of untreated aspen in contact with the ground varies widely. The life of aspen fence posts, ties, or mine timbers can not be predicted. It depends largely on the conditions under which the wood is used. Untreated aspen fence posts at a high elevation in the southwestern states are still serviceable after 28 years, altho all the aspen posts in a test fence in another location have been removed at the end of 10 years of service, and all but 15 per cent of the posts showed decay. Under favorable conditions, aspen may last only two or three years.

Adaptability to the Manufacture of Pulp and Paper

Aspen can be readily pulped by any of the standard chemical or mechanical processes. It is the standard pulp wood employed in the soda process for the production of certain grades of book papers. However, of the standard processes, the sulphite process probably offers the best prospects for better utilization of aspen in the Lake States. Many mills where such utilization can be made are already established in the Lake States, especially in eastern Wisconsin. These mills have difficulty in obtaining adequate supplies of the species commonly used for pulp and paper. The prospects are that the difficulties will increase with the depletion of the supply of spruce, balsam fir, and eastern hemlock. The large amount of aspen in the Lake States offers a possible solution to the raw material problem of these mills.

Aspen alone or mixed with softwoods is readily pulped by the sulphite process. The adaptability of aspen to pulping by the sulphite process, either alone or mixed with spruce, balsam fir, or eastern hemlock, has been demonstrated by tests made at the Forest Products Laboratory. The yield of pulp per cord of aspen will average about 950 pounds, approximately the same as the yield obtained from eastern hemlock. The unbleached pulp is of excellent color, but usually contains small black specks which disappear on bleaching. The pulp bleaches readily to a high white color. It is not so strong as pulp made from the softwoods[5] but it has other desirable characteristics, such as opacity, bulk, and softness. These properties are responsible for its use in book, tissue, and specialties.

Mills manufacturing sulphite pulp from softwoods can handle aspen satisfactorily with their regular equipment. About the only change that needs to be made in processing the pulp is the use of a set of smaller cut screen plates. Information on how to treat or process aspen pulp or mixed aspen and softwoods can be obtained from the Forest Products Laboratory at Madison, Wisconsin.

The sulphate and soda processes produce an easily bleached aspen pulp and give yields of from 45 to 50 per cent. These processes, however, are applicable to practically all North American hardwoods and in addition can be used with cornstalks and other materials.

Mills producing soda pulp are located largely outside of the Lake States. The available supply of raw material is much greater than in the case of sulphite mills, and the demand for soda pulp or sulphate pulp of an equivalent grade, shows little tendency to increase. The soda and sulphate processes, therefore, do not offer promising prospects for the utilization of the aspen stands.

The ground-wood process was first employed with aspen. For a long time it was not considered suitable for other woods. Spruce, however, has largely supplanted aspen in the production of ground-wood pulp because it requires less power for grinding and, in addition, gives a pulp of greater strength and better felting properties. Aspen ground-wood pulp is light colored and about 85 per cent of standard strength. Some aspen is now ground for use in newsprint paper and in boards. The complete substitution of aspen ground-wood pulp for spruce ground-wood pulp in newsprint would require an increase in the amount of chemical pulp to compensate for the lower strength properties.

Characteristics Depending on Combinations of Properties

Seasoning characteristics.—Manufacturers are experiencing no difficulty in air-drying aspen. The wood has shown no tendency to surface check or warp excessively, nor has it exhibited any other serious seasoning troubles.

The literature on aspen and the lumber trade in general ascribe to

[5] The strength properties of unbleached aspen pulp and of pulp made of a mixture of one-half aspen and one-half white spruce and a mixture of one-half aspen and one-half eastern hemlock are shown in detail in an article entitled, "Pulping of Hardwoods and Mixtures of Hardwoods and Conifers by the Sulphite Process," by William H. Monsson, Forest Products Laboratory, published in Paper Trade Journal, April 26, 1928.

it a tendency to warp. The small amount of information available does not reveal the cause of this general opinion. A number of one-inch boards and resawed inch stock were dried at the Forest Products Laboratory to about 12 per cent moisture content. The thin resawed stock furnished a severe test of warping tendencies. A careful inspection of the specimens showed that the thin, as well as the thicker, specimens held their shape well. Only one specimen showed pronounced warp. Inspection of a shipment of rough 4/4 air-dried stock at about 16 per cent moisture content showed little warping; in fact, no more than would be expected of any of the principal commercial hardwoods. In a test made at the Forest Products Laboratory of the kiln-drying of aspen dimension stock 1 by 1 inch and also 3 by 3 inches in cross section, and 48 inches long, the stock was dried without developing any pronounced defects, such as collapse, honeycombing, excessive surface checking, or warping. The blanks remained sufficiently straight for furniture stock and the warping was less than that shown by the red gum and yellow birch blanks, which were also tested.[6] Thus the general opinion that aspen has a pronounced tendency to warp may have resulted from lack of care in seasoning; from a comparison with white pine, which is one of the best of our native species for holding its shape; or it may have developed from observing the pronounced warping sometimes observed in boards cut from small, rapid growing trees.

No extensive research has been conducted at the Forest Products Laboratory to determine the most efficient methods of air- or kiln-drying aspen. Experience with other species, such as the gums, however, indicates that aspen can be successfully dried by modern methods.

Until more adequate data are available the kiln schedules recommended for drying birch[7] can be used for drying aspen. The kiln schedule of the Forest Products Laboratory for birch of 6/4 inch thickness or thinner recommends temperatures from 140 degrees initial to 170 degrees F. final, and relative humidities from 80 per cent initial to 20 per cent final. Such a schedule is safe for aspen in so far as preventing honeycombing, collapse, and excessive checking.

Ability to stay in place.—Ability to maintain size and shape is a desirable property in practically all uses into which aspen goes. Tho not the most important, it is probably the most generally desired of the properties. Tendency to change size or shape increases the difficulty of construction and fabrication, injures appearance, and adversely affects service. The desirability of retaining size and shape

[6] The results of the tests are presented in a report, "Kiln Drying of Small Dimension Stock," by R. H. Grabow, Forest Products Laboratory, Madison, Wisconsin.

[7] For schedules on drying birch see "Kiln Drying Handbook," Department of Agriculture Bulletin No. 1136, p. 49.

in such uses as hosiery boards, furniture, doors, fixtures, shoe lasts, sashes, woodenware, dimension stock, and forms is well known. Siding and sheathing that fail to stay in place not only cause leakage in walls but also mar the finished appearance of the structure.

The ability of aspen to stay in place depends upon a combination of its shrinkage and tendency to warp. Shrinkage causes a change in dimension; warping results in a change in shape. The smaller these changes, the better the wood stays in place.

A comparison of the tendency of aspen and several other woods to change dimension with changes in moisture conditions is shown by the shrinkage comparison in Figure 8. The unequal shrinkage of heartwood and sapwood, the abnormal shrinkage of compression wood, the presence of knots and cross grain, and the difference in shrinkage of flat grain and edge grain in boards from near the pith cause warping. No satisfactory method of evaluating all these factors for different species has yet been devised. Comparison of the ability of aspen to stay in place with that of other kinds of woods can not, therefore, be made with assurance. Altho a definite comparison can not be made, a conclusion can be drawn from the shrinkage values for aspen and the frequency of occurrence of the other factors that cause warping.

Aspen has a low shrinkage comparing favorably with many of the hardwoods. It is straight grained, being similar in this respect to basswood and yellow poplar. Only an occasional board of aspen contains both heartwood and sapwood and consequently there is practically no warping due to unequal shrinkage of heartwood and sapwood. Abnormal compression wood has seldom been observed and is responsible for little if any warping in aspen. The occurrence of knots is largely a matter of grade. For the same grade knots will probably cause no more warping in aspen than in other woods. In the mill run of aspen, knots cause somewhat more warping than they do in basswood or cottonwood because the small size of the aspen tree results in a larger number of boards from near the pith than is obtained from species with larger diameters. Thus it appears that aspen should stay in place well when compared with other hardwoods. The small number of tests made at the Forest Products Laboratory on aspen and the experience of at least one consumer confirm this observation. However, additional service records and experimental data are necessary to determine more definitely the ability of aspen to stay in place.

Gluing characteristics.—Glued joints that are as strong as the wood itself are easily obtained with aspen (Fig. 17A). Such joints are obtainable with animal, casein, or vegetable glues. Recent tests at the Forest Products Laboratory of joints made with these glues resulted in an average joint strength of 1,725 pounds per square inch.

Joint failures were either entirely or almost completely in the wood. All of the joints made with casein or vegetable glue showed 100 per cent wood failure. Joints made with animal glue were prepared under good and also under poor gluing conditions. All the joints made under good conditions failed 100 per cent in the wood, and even those that were made under poor conditions failed on an average of 97 per cent in the wood. With all glues and under all conditions of gluing the joints made were as strong as the wood itself.[8] The development of the full strength of aspen with joints made under conditions that in many other woods result in starved joints marks the species as one of the easiest to glue.[9]

Joints made with animal glue under conditions that were more severe than would be employed in a commercial gluing operation, showed only 3 per cent of the failures occurred in the glued joints (Fig. 17B). Moreover, the joints developed an average strength of

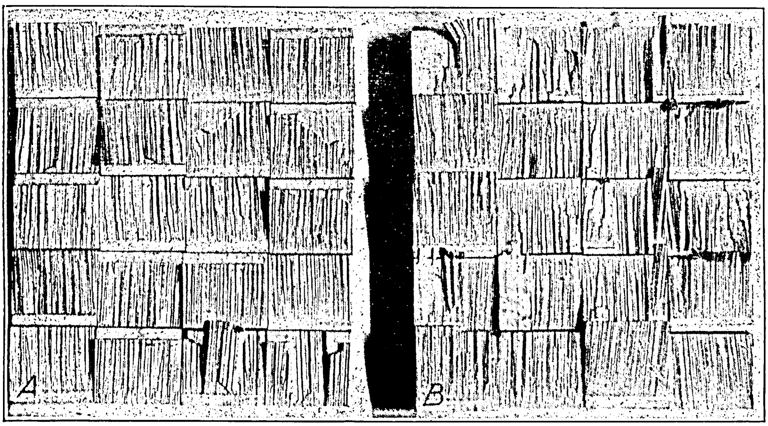

Fig. 17. Characteristic Joint Failures in Aspen Glued with Animal Glue. Even Under Poor Gluing Conditions Most of the Glued Joints Were Stronger Than the Wood

A. Joints glued under good conditions with animal glue. All failures are in the wood. The failures are also typical of those obtained with casein and vegetable glue.

B. Joints glued under poor conditions with animal glue. The smooth surface on some of the specimens shows where the glue rather than the wood failed.

1,705 pounds per square inch. Aspen can, therefore, be glued satisfactorily with animal glue under a wide range of conditions. This is an advantage in commercial operations in that it is an insurance against poor joints. In addition, gluing operations do not have to be so carefully watched and controlled to obtain satisfactory results.

[8] Gluing schedules A1, C1, and V1, recommended in Tables 7 and 8 of U. S. Dept. of Agr. Bul. No. 1500 for animal, casein, and vegetable glues are satisfactory for the gluing of aspen.

[9] Results of similar gluing tests on 40 other species are shown in U. S. Dept. of Agr. Bul. No. 1500.

The excellent gluing characteristics of aspen adapt it to use for core stock for doors, veneer panels, and similar products. The use of veneers, built-up construction, and other glued-wood products has been steadily increasing for a number of years. The demonstrated excellent gluing characteristics of aspen, therefore, open a number of new markets for it.

Painting and finishing characteristics.—Very little information is available on the painting and finishing characteristics of aspen. A study of the painting characteristics of aspen and a number of hardwoods was started at the Forest Products Laboratory in 1930. It will require two or three years to obtain sufficient data to warrant the drawing of definite conclusions or the making of definite recommendations. Certain general and tentative conclusions can, however, be drawn at this time from data available and general knowledge of the properties and characteristics of the wood.

Aspen is better adapted to paint and enamel than to stain and natural finishes. The uniform texture, light weight, and color indicate that it will take and hold paint well. Good painting characteristics are an important requirement of wood for interior and exterior trim. A few trials made on aspen indicated that the dark streaks which occur in the wood and around the knots can be satisfactorily covered with three coats of white lead paint. No other type of paint has been tried on aspen at the Forest Products Laboratory. A single coat of enamel applied on the three-coat white lead base gave a finish which indicated that aspen can be satisfactorily used for high-class, light-colored enamel work. The wood is reported to take stain well and such figure as the wood has shows up well. Where a pronounced figure is not desired it should prove satisfactory in stain and natural finishes. The wood, therefore, has possibilities for stained and enameled furniture, and for painted or enameled interior trim.

Treating characteristics.—Aspen that has received a good preservative will generally give longer life at lower cost per year than the naturally decay-resistant woods without treatment. Aspen posts that have been pressure-treated with a 25 per cent coal-tar creosote and 75 per cent gas oil mixture have given 13 years service at Madison, Wisconsin, and are still sound.

When pressure-treated material is not available or the cost is too high, the user can do his own treating on the farm, at the mine, or on the job by the hot and cold bath process.[10] It is estimated that under conditions favorable to decay a life of 20 years or more can be expected from aspen posts treated with creosote by the hot and cold

[10] The hot and cold bath treatment is described in U. S. Dept. of Agr. Farmers' Bull. No. 744, "The Preservative Treatment of Farm Timbers."

bath process. Water-gas-tar or a half and half mixture of waste crank-case oil and creosote applied by the hot and cold bath method will probably give a reasonably long life to aspen, but data are not available on which to base a comparison with the coal tar-creosote treatment.

Aspen may also be treated with water solutions, such as zinc chloride and sodium fluoride. These chemicals are best applied by pressure. They may be applied, but with less effective results, by the simple method of soaking well-seasoned wood for a week or more in a tank containing a 5 per cent solution of zinc chloride or a 3½ per cent solution of sodium fluoride. Detailed instructions for preparing solutions and treating by the steeping process may be obtained from the Forest Products Laboratory, Maidson, Wisconsin.

The more effective methods described when applied to aspen make it an economical wood to use under conditions favorable to decay. The life of aspen that has been well treated with preservatives will not differ greatly from that of well-treated material of the more decay-resistant woods. The possibilities of using preservative-treated aspen for many purposes for which the untreated wood is unsuited have been largely overlooked.

Ease of working.—Aspen is an easy wood to work. It is soft and easy to cut, saw, and shape with hand tools. It has a uniform texture and is consequently easy to finish to a smooth surface. Aspen, in both ease of working and character of surface obtainable, is similar to basswood and yellow poplar, both species well and favorably known for their working qualities.

Only easy working woods are suitable for match stock. The use of aspen in the manufacture of matches is a testimonial to the working qualities of the species. Toys, shoe pegs, clothespins, novelties, toothpicks, and woodenware are other products in which aspen is being used because of the ease with which it is worked. Aspen has possibilities in all uses where ease of working, both as to labor and power consumed and character of surface obtainable, is an important or essential requirement.

Altho aspen can be worked with tools that would be impracticable with harder and less uniform textured woods, the use of such tools results in much poorer surfaces. Poor surfaces from dull tools lose for aspen some of the advantages resulting from the smoothness and silky luster of the well-finished wood.

Tho dry aspen dresses to a smooth surface, the wood, when wet, has a tendency to fuzz when dressed. This is a common characteristic of the softer hardwoods, such as aspen, basswood, yellow poplar, and cottonwood, and should be recognized and avoided by proper seasoning before dressing.

Grading of Lumber

Aspen is graded under both hardwood and softwood rules. It is graded as hardwood factory lumber under the rules of the National Hardwood Lumber Association and as softwood yard lumber under the rules of the Northern Pine Manufacturers' Association. Some mills grade the entire output of aspen under the pine rules, whereas at least one large mill grades the upper grades of aspen under the hardwood rules and the lower grades under the softwood rules.

The best utilization of aspen can probably be obtained by using both the hardwood and softwood rules. Most of the industrial uses to which aspen is best adapted require small, clear pieces rather than full-sized boards. The hardwood grades, with the exception of the grade Firsts and Seconds, are cutting grades, and therefore best meet the requirements of such uses. On the other hand, uses, such as crating, boxes, and building items, use common lumber containing knots and other defects. The softwood grading rules are better adapted to the requirements of such uses for they are based on size, quality, and character of the defects.

The following discussion of grades for aspen, therefore, describes the four best hardwood grades: Firsts and Seconds; Selects; No. 1 Common; and No. 2 Common, and also the three lowest softwood grades: No. 3 Common; No. 4 Common; and No. 5 Common. Such a division is purely arbitrary. In practice the demand for the various grades largely determines the grading system applied. Thus, No. 2 Common will probably be graded by hardwood or softwood rules depending upon the nature of the demand for that type of lumber. In fact the companies producing the most aspen are trying out various possibilities with reference to grading and eventually the method followed will probably be determined largely by the type of uses in which aspen finds the most favor.

Under the hardwood rules, aspen grades are identical with those for sap gum, cottonwood, black gum, tupelo, magnolia, and willow. The grades are Firsts and Seconds, Selects, No. 1 Common, No. 2 Common, and No. 3 Common. Sound stain is no defect in any of these grades. They are all standard hardwood grades except No. 2 Common, which requires "sound" instead of "clear face."

The combined grade of Firsts and Seconds in aspen must, under hardwood rules, contain not less than 33 1/3 per cent of Firsts. Figure 18A shows three boards of First and Second grade. The right-hand board is a first and the other two are seconds. Firsts must be 6 inches or more in width and 8 feet or more in length, except that clear pieces 5 inches wide by 10 feet long or longer are admitted. Pieces with 4 to 9 feet surface measure must be clear. Seconds must also be more than 6 inches wide and must be 8 feet long, except that a limited number of clear pieces 5 inches wide and 10 feet long and more are admitted. Aspen is generally cut from small trees and Firsts and Seconds are

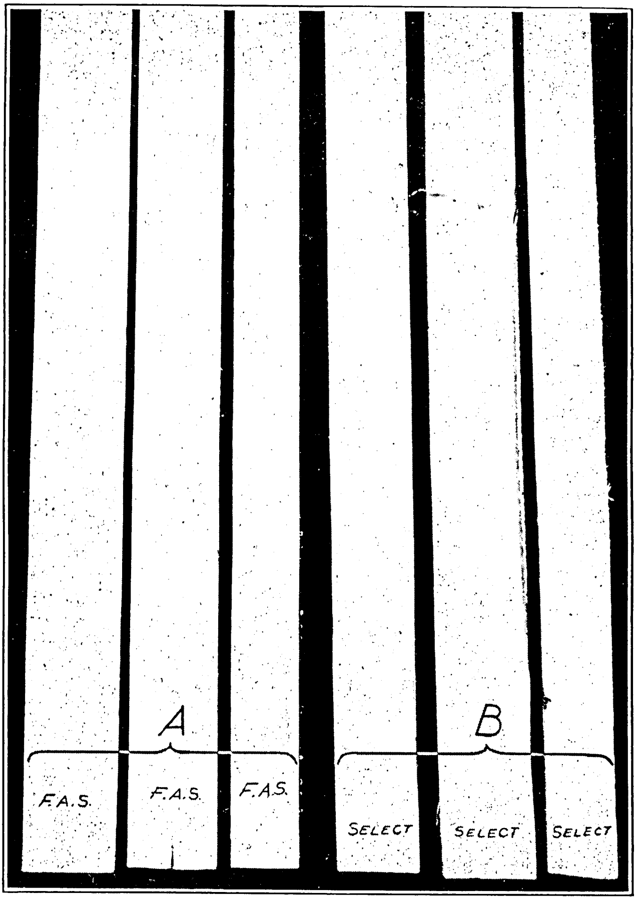

Fig. 18. Firsts and Seconds and Select Aspen as Graded Under Hardwood Grading Rules

A. Firsts and Seconds in aspen are usually clear or contain only one or two defects because of the small size of the boards. The grade is suitable for uses requiring practically clear, full-sized boards.

B. Selects in aspen are suitable for uses requiring large, clear cuttings or for uses that can utilize large cuttings and boards with clear faces but No. 1 Common backs.

therefore largely clear stock. The boards are seldom large enough to permit more than one standard defect[11] in Firsts and two standard defects in Seconds.

Selects must be 4 inches or more in width. Pieces that are 4 to 6 inches wide, however, must be 8 feet long or more and must be prac-

[11] Standard defects are defined in the National Hardwood Lumber Association Rules, pages 15 and 16, paragraphs 29-33, January, 1930.

tically clear. Pieces 6 inches and more in width and 8 feet and more in length must grade Seconds on the best face and not below No. 1 Common on the poorest face. In addition, the grade also admits boards over 10 feet in length that are not less than 6 inches in width and from which material with a practically clear face and sound No. 1 Common back can be obtained by cutting out defects. Figure 18B shows the type of board commonly found in the grade.

No. 1 Common pieces must be 3 or more inches in width and 4 feet or more in length. The permissible amount of material 3 inches in

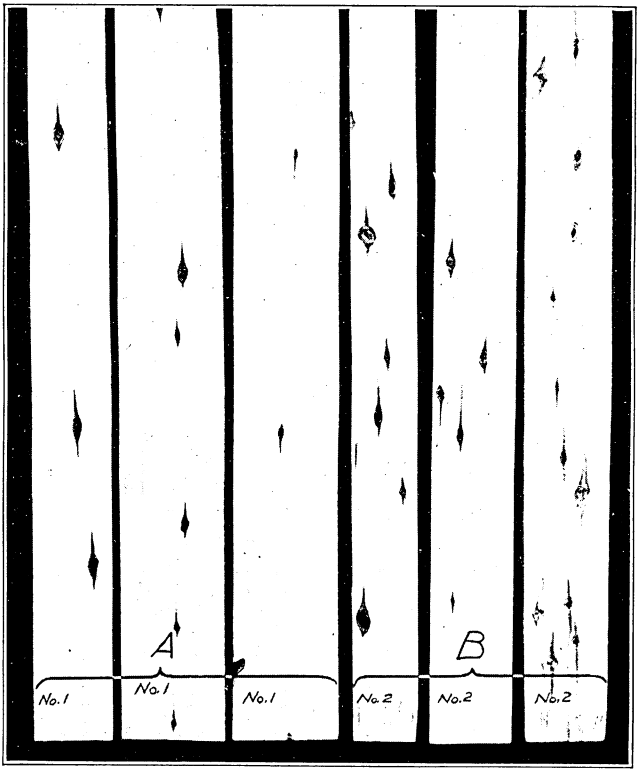

Fig. 19. No. 1 Common and No. 2 Common Aspen As Graded Under Hardwood Grading Rules

A. No. 1 Common aspen boards. The grade is suitable for uses that require some fairly large cuttings but can also utilize a number of small ones.

B. No. 2 Common aspen boards. The grade is suitable for uses requiring only small cuttings.

width or less than 8 feet in length in a shipment, however, is limited to a small proportion of the whole. In addition, short pieces 4 to 5 feet and narrow pieces 3 to 4 inches wide and 6 to 7 feet long must be clear. The larger pieces must produce a two-thirds clear face in from 2 to 4 cuttings. The number of cuttings permitted depends on the size of the pieces. Figure 19A shows the type of boards found in No. 1 Common grade.

No. 2 Common must be 3 or more inches in width and 4 feet or more in length. Lengths under 8 feet are limited to 30 per cent of a shipment. All material must produce 50 per cent clear face in from 3 to 5 cuttings. The number of cuttings permissible depends upon the size of the pieces. Figure 19B shows the type of boards found in No. 2 Common.

Fig. 20. No. 3, No. 4, and No. 5 Common Aspen Boards as Graded Under Softwood Grading Rules. All Grades Permit Some Waste. The Dark Streaks in the Photographs Are Not Decay and Cause the Grades as Pictured to Appear Poorer Than They Are

A. No. 3 Common. The large coarse-knotted character of the grade is shown. The grade is suitable for rough coverage.

B. No. 4 Common. Low quality lumber admitting the coarsest defects, such as decay and holes. The grade is suitable for crating.

C. No. 5 Common. Must hold together under ordinary handling. The board on the left contains decay which does not show in the photograph. The grade is used largely for rough crating.

Boards of the type commonly found in No. 3 Common, No. 4 Common, and No. 5 Common, as graded under Northern Pine Manufacturers' Association Rules, are shown in Figure 20. Such boards are used as a whole for rough coverage and similar uses or are cut into required sizes for such uses as crating, backing, or lining. No. 3 Common, Figure 20A, illustrates the large, coarse knotted type of stock typical of the grade. Other defects permitted in the grade, such as firm decay, streaks, occasional knot holes, loose and unsound knots, are also shown. About 20 per cent of the run of aspen is No. 3 Common. The No. 3 Common is sometimes combined with the hardwood grade of No. 2 Common and sold as No. 3 and better. The combination "sweetens" the No. 3 grade considerably as may be seen in Figure 19B.

Decay is the predominating defect in aspen No. 4 and No. 5 Common. In addition, large knot holes, wane, and shake are common. No. 4 Common is low quality lumber, generally usable as a whole, but permitting some waste. No. 5 must hold together under ordinary handling and ordinarily require some cutting. About one half of the aspen cut falls into these two grades.

Barky strips is a special grade of aspen used largely for crating. As the name implies a large amount of wane is the outstanding characteristic of the grade. Material of this grade is only suitable for uses that can utilize rough, undressed, comparatively narrow stock containing considerable bark.

In applying the data on properties, careful consideration should be given to the grades. The defects permitted in the grades not only have an important influence on the serviceability of lumber, but may modify the comparisons of properties previously presented. Only a glance is necessary to show that the strength properties of the boards shown in Figure 18 differ materially from those in Figure 20. The comparison of the properties of aspen with those of other species given in this bulletin holds only for the clear wood or between grades having like defects.

Necessity for Further Research on Properties

Information on the properties of aspen is by no means complete. Additional research is necessary to supplement existing data on some properties, such as shrinkage, seasoning, and decay resistance. In addition, there is little information on the painting and finishing characteristics of the species, or on the best method of preservative treatment.

Shrinkage data are needed to enable users to determine the average amount of shrinkage or swelling that takes place with any given change in moisture content. Present data give only the average total shrinkage from a green to an oven-dry condition. Both kiln-drying and air-drying studies are needed to determine the best kiln schedules, methods of piling, and possibilities of decreasing seasoning degrade. Service records on untreated aspen are needed to determine in what uses the decay hazards are too high to permit profitable use of the wood untreated and to determine how well wood stays in place.

There is practically no information on how aspen will take and hold paint when exposed to weather, or on the possibility of using the wood with natural finishes, and only a small amount of information is available on how it will take enamels on interior finishes. Tests now under way at the Forest Products Laboratory will furnish information on the painting characteristics of wood when exposed to weather.

Additional research on properties should aid in the better utilization of the aspen stands of the Lake States. It will permit the species to be used with assurance whereas consumers now hesitate to incur risk of unsatisfactory service. Further research should aid in preventing the use of the species for purposes to which it is unsuited and thus prevent the development of prejudices which tend to retard the use of the species for purposes to which it is suited. Possibly, additional research may point the way to better seasoning methods that will decrease losses between the timber operators and the ultimate consumers and thus make the marketing of aspen more profitable.

UTILIZATION[12]

History of Use of Aspen in the United States

Aspen has long been regarded in the United States as an inferior species. This attitude is due chiefly to the relatively small size of the mature tree and the prevalence of heart rot and decayed knots, rather than to serious deficiencies in the technical or mechanical properties of the wood. It is true that aspen wood lacks unusual strength and any marked natural resistance to decay, but for many uses lack of strength and decay resistance is not, and should not be, considered a limiting factor in its use.

Small sized trees with numerous defects yield only a limited amount of clear lumber. As long as logs of other tree species, larger in size than aspen, were available at a moderate price, little urge existed for utilizing aspen. With a decrease in the availability of basswood, yellow poplar, and several other woods, the possibilities of using aspen wood for certain purposes became apparent.

Altho numerous references are made to the utilization of aspen in literature, practically no complete analysis has ever been made of the situation. In most studies of wood-using industries made by the several states, from time to time, the amount of aspen used is included in the general group "other species." In other estimates of lumber manufacture, aspen is included with cottonwood. The scarcity of any reliable figures on aspen consumption in the past makes it impossible to trace any definite trends in its use.

[12] This section included under the general heading "Utilization," which deals with the use of aspen wood and lumber, was written by Henry Schmitz, chief of the Division of Forestry, University of Minnesota, St. Paul, Minnesota.

Notwithstanding the fragmentary references to the use of aspen, it is nevertheless apparent that a tremendous change in attitude toward its use has taken place. F. Andrew Michaux in 1859 refers to the wood of aspen as "light, soft, destitute of strength, and of no utility." "These defects," says Michaux, "are not even compensated by an ample size and rapid growth." Michaux was, of course, not only misinformed, but unable to visualize the tremendous number of different uses to which lumber would be put in the future. The very characteristics which Michaux thought were limitations now make aspen preferred for certain uses.

Aspen is utilized to a certain extent almost everywhere it grows, but it is cut in comparatively large amounts only in Minnesota and Wisconsin. Even in these states, the exact cut is unknown, but it is estimated that during 1928 approximately 71,000,000 board feet and 100,000 cords of aspen were cut in Minnesota. No estimate of the total cut of aspen in Wisconsin during the same period is available, but in 1926 at least 33,000 cords of aspen pulp wood, 35,000 cords of excelsior wood, and 4,800,000 board feet of aspen crating lumber were used in that state.

In general, it appears that the consumption of aspen pulp wood will materially increase. It also appears that, owing to certain desirable characteristics, the consumption of aspen dimension and crating stock will greatly increase. Undoubtedly, too, the use of aspen fence posts and mine timbers will increase in the Lake States in the future. The future trend in the consumption of aspen lumber will depend, to some extent at least, on economic considerations.

At the present time, the price of aspen lumber is comparatively low, but as the intrinsic merits of the wood become more fully understood and additional markets are found for it, higher prices will undoubtedly prevail. Aspen saw logs in 1929 sold for from $21 to $22 per thousand feet, board measure, depending on the size and quality. Prices at shipping points were these prices less the freight to the mill.

The Use of Aspen in Europe

It is impossible to draw final conclusions concerning the future use of aspen in America from the use of the European aspen. This is due to the fact that not only is a somewhat different tree dealt with, but also because of the different wood requirements and different economic conditions existing in Europe and America. Nevertheless, a study of the utilization of European aspen may throw some light on the trend which may take place in the use of aspen in America.

Populus tremula is considered a very desirable tree in European countries, particularly Norway, Sweden, and sections of Russia, because of its suitability for the manufacture of safety matches. When and where this market for aspen exists, the tree is favored in silvicultural systems and other tree species are sacrificed for it.

The total amount of wood required by the match industry is not so large as might be expected. Sweden, the largest producer of safety matches in Europe, requires approximately 150,000 cubic meters of match wood, of which almost two thirds is aspen and one third, birch and alder. Thus the annual requirements of aspen by the Swedish match industry is less than 40,000 cords. If aspen of good grade were readily available, it is quite likely that birch and alder would not be used in the manufacture of matches in Sweden. Only the best quality of timber can be used in the production of matches.

In certain sections of Russia where cement is manufactured, European aspen is used for slack cooperage for cement barrels. Wood used for this purpose must be free from large rotten knots. In the United States the cement barrel has all but disappeared, cloth and paper bags having almost entirely taken its place. As in America, aspen is used quite extensively for the manufacture of so-called "wood wool," which is equivalent to our excelsior and used for similar purposes.

Throughout Europe, where aspen occurs naturally, or can be imported at a reasonable figure, many minor uses have been developed for the wood. It is used widely, for example, in the manufacture of boxes, baskets, crates, and berry boxes of various kinds. In England, the wood used for these purposes is imported from northern Russia and in lengths of 7 to 9 feet with diameters of 8 to 16 inches. Aspen is also used in England and on the Continent for dry (slack) cooperage, particularly for food containers. In central Europe and elsewhere, it is used extensively in the manufacture of toys and novelties.

Lumber

That aspen can be used for lumber and that such lumber will give good service under certain conditions have been amply demonstrated. Time alone can tell how successfully it can compete in the market with other woods.

Considerable quantities of aspen have been and are cut into lumber by portable sawmills, particularly in Minnesota. This lumber is used by settlers for practically all ordinary purposes. Unless it has received a preservative treatment, however, it should not be used in contact with the soil or in damp places which are favorable to decay.

Aspen has also been cut commercially for lumber in Minnesota for years and a number of special markets have been developed. Some of the planing mill products are illustrated in Figure 21.

The size of aspen in the Lake States accounts for the small dimensions of aspen lumber products. Products of larger sizes than 2 by 12 inches or 4 by 4 inches are exceptional.

Among the important characteristics of aspen wood that make it suitable for certain purposes are:

1. Combination of strength and light weight
2. Small tendency to split in nailing
3. Excellent gluing characteristics
4. Lack of pronounced odor
5. Combination of softness and uniform texture
6. Complete absence of pitch
7. Light color
8. Ability to withstand sanding without raising grain
9. Suitabality for painting

Much promotional work will undoubtedly be necessary before the market for aspen lumber will be greatly extended. Enterprising producers of aspen lumber are undertaking this work and their efforts will undoubtedly be worth while.

Planking and flooring.—For the last two years, the Minnesota Department of Highways has been experimenting with the use of aspen as an alternate for rock elm and oak, which are ordinarily used for planking longitudinal wearing courses on bridges. The material used is sawed and surfaced to 1 7/8 inches in thickness and from 6 to 12 inches wide. Aspen planking stands up well under the wear and tear of highway traffic. According to the reports received, aspen roughs up and forms a "fur mat" that is quite resistant to wear. When aspen planking in wearing courses in bridges is dented by tractor lugs, the fibers apparently are not cut and they return to their normal position in a short time. Similar treatment cuts the fibers of harder woods, such as elm or oak, and the planking deteriorates rapidly under continued abuse.

Aspen planking used for this purpose, or for any other where decay conditions are favorable, must be treated with suitable wood preservative. The Minnesota Highway Department now gives bridge planking an empty cell treatment with coal-tar creosote with a final retention of six pounds per cubic foot. Aspen planking has long been used for barn floors because of its resistance to mechanical wear.

Some softwoods of light color and uniform texture have recently been used successfully for floors in dwellings, gymnasiums, and armories. Aspen, however, is softer and lighter-colored than any of the woods so far used. It may dent and mar too easily to be satisfactory or its light color may not prove popular. A few installations are necessary to determine whether aspen is a desirable wood for high-class flooring. It is possible that factory floors of aspen wood blocks might prove successful. Blocks used for this purpose are ordinarily treated with a wood preservative to render satisfactory service; aspen should be no exception to this practice.

Interior trim and finish.—Probably one of the most promising fields for aspen lumber is interior trim and finish. Its small tendency to split in nailing, lack of resin, reaction to sanding, and suitability for painting comply with most of the requirements for interior trim or finish, especially when it is to be painted or enameled. Aspen wood shrinks no more than other woods commonly used for this purpose and less than others. Items of interior trim now manufactured from aspen are shown in Figure 21.

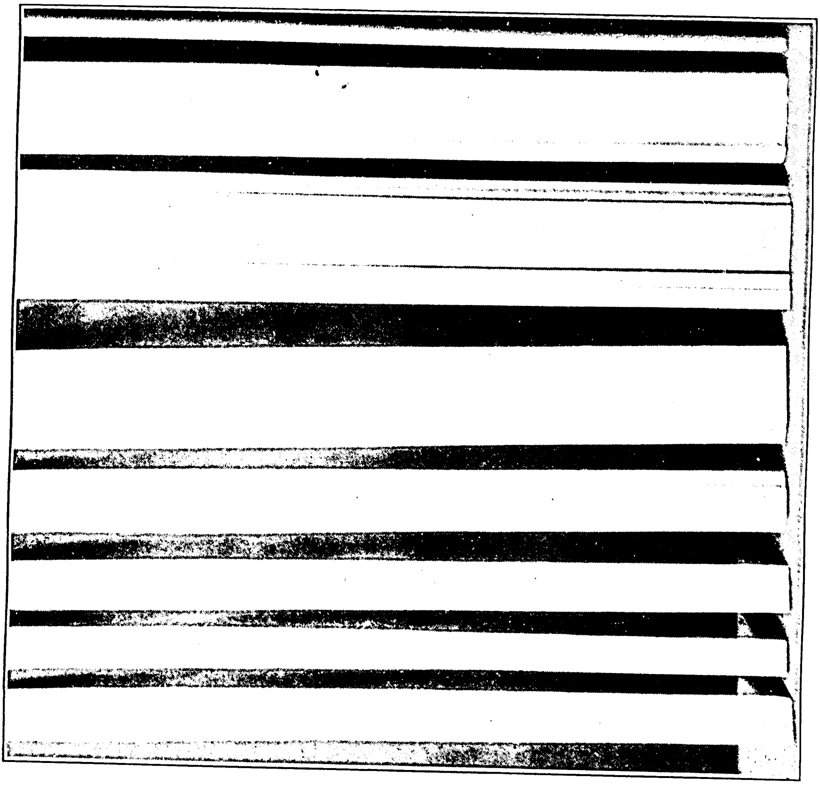

Fig. 21. Types of Aspen Molding Stock

Exterior trim.—Woods very similar to aspen in properties and characteristics have been used extensively in the past for exterior trim. Basswood and yellow poplar siding, cornice, and trim are found on a number of old houses. The demand for these woods for special and more exacting uses has very largely removed them from the exterior trim market. Aspen will probably have a somewhat similar develop-

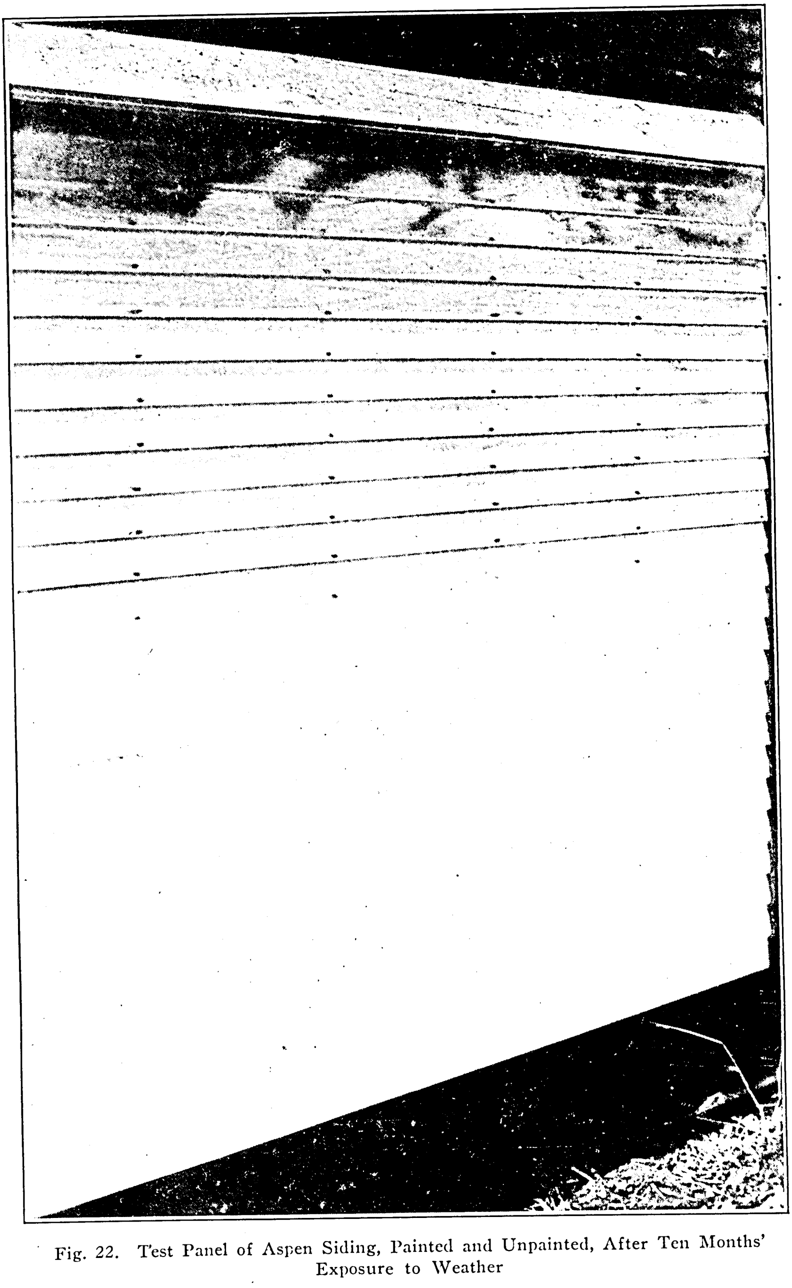

Fig. 22. Test Panel of Aspen Siding, Painted and Unpainted, After Ten Months' Exposure to Weather

ment. The properties of aspen and the results of tests now in progress indicate that it will meet requirements satisfactorily for exterior trim. Figure 22 shows painted and unpainted aspen siding after ten months' exposure to weather. Additional tests now started will furnish more detailed data on aspen exposed to the weather at widely scattered points throughout the United States.

Much exterior trim is narrow, that is, six inches or less in width. Aspen must go largely into uses that can utilize narrow stock, for the small size of the aspen tree results in the production of large amounts of narrow stock. Until a demand from specialized and exacting uses has developed, a portion of the cut will probably find a market locally as exterior trim.

Boxes and Crates

About 3½ billion board feet of softwoods and more than one billion feet of hardwoods were used in the United States in 1928 for boxes and crates.[13] This amounts to approximately 15 per cent of the total lumber cut annually. During recent years, the fiber carton and the veneer box have been used in increasing amounts. There seems to be little reason to believe, however, that the amount of lumber used for boxes will decrease very rapidly in the near future. As a matter of fact there are some indications that, as the number of people concentrated in urban and industrial centers increases and food and other goods must be shipped greater distances, the demands for boxes, crates, and other types of containers will increase.

To be used extensively for boxes and crates, a wood must have certain characteristics and properties, chief of which are: (1) lightness

TABLE X

AVERAGE SPECIFIC GRAVITY OF VARIOUS WOODS AND THE WEIGHT OF EMPTY BOXES CORRECTED TO 15 PER CENT MOISTURE CONTENT

Species	Average specific gravity	Weight of empty box in pounds at 15 per cent moisture content
Aspen	0.362	6.33
Lowland white fir	.362	6 43
California red fir	.355	6.47
White fir	.363	6 54
Silver fir	.385	6.72
Western yellow pine	.393	7.16
Lodgepole pine	.437	7.63
Western hemlock	.432	8.16
Western larch	.562	9.44

in weight, (2) strength, (3) nail-holding capacity, (4) appearance and workability, and (5) the absence of odor and taste. There is probably no such thing as an ideal wood for boxes and crates, but aspen seems to combine to a remarkable extent many of the required characteristics.

[13] The figures on the consumption of lumber for boxes and crates were obtained from a canvass conducted by the Forest Service in co-operation with the Bureau of the Census, United States Department of Commerce.

Aspen is one of the lightest of the hardwoods generally available for box shooks and crating material. A study made by the Forest Products Laboratory of the suitability of certain little-used woods for shipping containers shows that aspen produced the most serviceable box on the basis of weight of any of the species tested. The relative weight of the woods included in this study is given in Table X.

Altho aspen is not a strong wood, generally speaking, it possesses sufficient strength for all ordinary crating and boxing purposes. The bending strength of clear aspen is about the same as that of northern white pine and more than that of many other woods commonly used for boxes. Tests made from different woods show that boxes made of aspen are almost as satisfactory as those made of lodgepole and western yellow pine.

One of the most important considerations in using wooden containers for food products, such as cheese, butter, and fresh and smoked

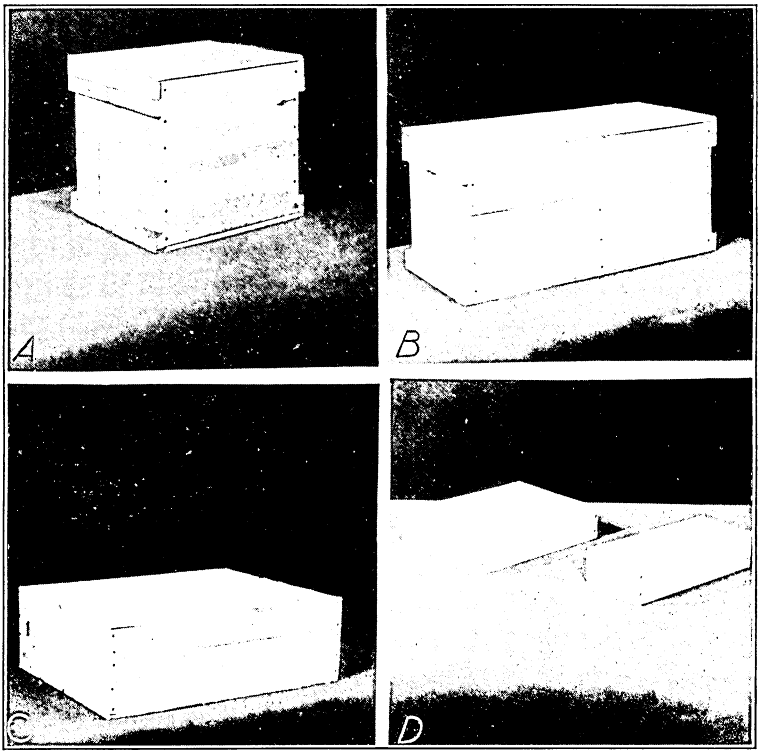

Fig. 23. Food Containers Made from Aspen
A. Farmers' heavy-duty egg case; fifteen-dozen size, made entirely of aspen.
B. Farmers' heavy-duty egg case, thirty-dozen size, made entirely from aspen.
C. Shipping box for dressed poultry made from aspen.
D. Cheese boxes, two- and four-pound sizes, made from aspen.

meats, is the absence of any pronounced odor and taste. Aspen wood is practically odorless and tasteless, and can be used with safety. The light color, soft texture, and smooth finish of the wood also adds much to the general appearance, so important in food containers.

Various types of boxes and crates made of aspen are shown in Figures 23 and 24. These have given very satisfactory service and there seems to be no reason why new and extended uses for these products can not be developed.

Minnesota, Michigan, and Wisconsin used about 554,000,000 board feet of lumber for boxes and crates in 1928. How much aspen contributed to this total is not known. In St. Paul and Minneapolis over 4,000,000 board feet of aspen were used for boxes and crates in 1928.

Excelsior

At the present time somewhat more than 200,000 cords of wood are used annually for the manufacture of excelsior. In the Lake States and New England States, where the industry is more concentrated, cottonwood and aspen are used extensively. Basswood, tho preferred, is used in smaller quantities. In the South and along the Atlantic seaboard, loblolly and shortleaf pines are used. Other woods used include western yellow pine and Douglas fir, particularly on the Pacific Coast; red gum in the South; and spruce, hemlock, and chestnut.

The qualities most desired in excelsior wood are toughness, light color, light weight, and freedom from odor. Basswood is generally believed to meet these requirements most fully, but scarcity and high prices militate against its wide use. It is estimated that not more than 11 per cent of the total annual production of excelsior is manufactured from basswood. Aspen wood meets all the essential requirements for excelsior; it is tough, white in color, comparatively straight grained, and free from odor. It is quite likely, therefore, that the use of aspen will continue to increase for the manufacture of excelsior.

A recent survey of wood requirements of the excelsior manufacturers of Wisconsin indicates that approximately 33,000 cords of aspen are used annually in that state. Minnesota manufactures only a comparatively small amount, but most of that which is manufactured is made from aspen. Figures on the use of aspen for excelsior manufacture in Michigan are not available, but as Michigan is one of the most important producers and aspen supplies are quite abundant, it is likely that a considerable quantity of aspen is used annually for excelsior.

The large production of excelsior in the state of Michigan is, no doubt, somewhat influenced by the requirements of the furniture industry of that state. Until additional local markets are found to

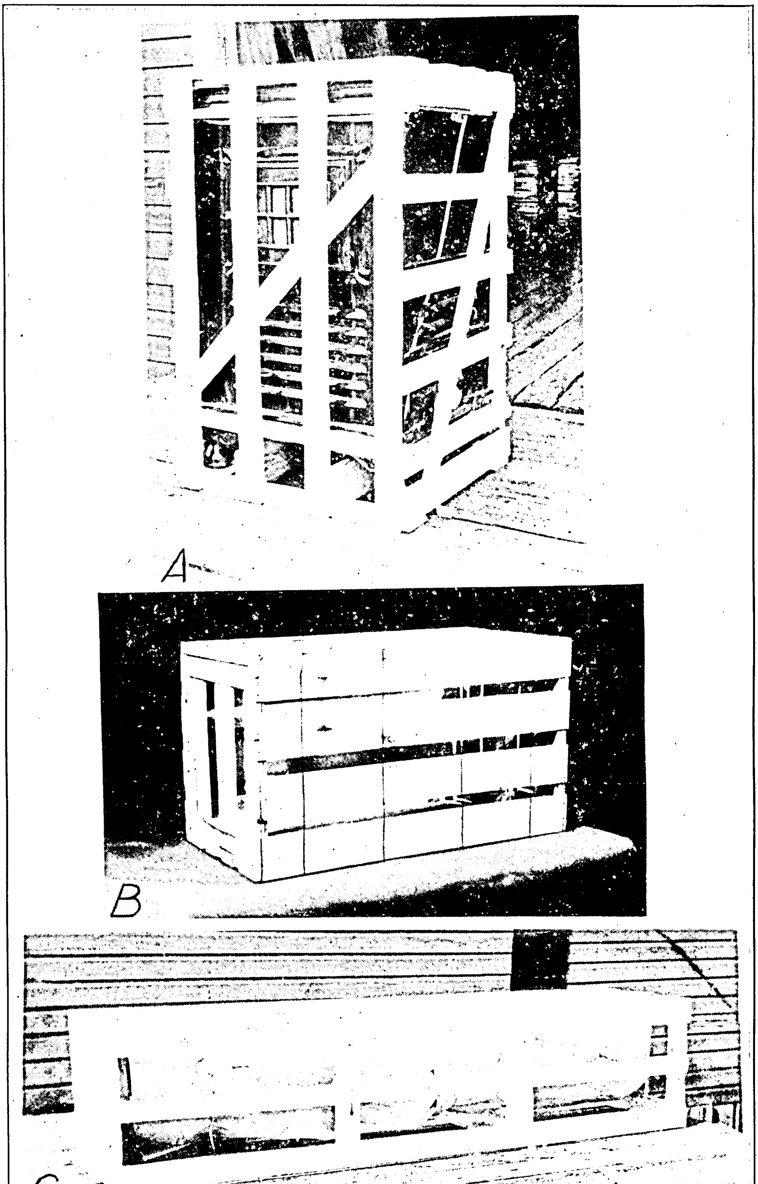

Fig. 24. Crates Made from Aspen
A. Aspen crate for home heater.
B. Wire-bound aspen crate.
C. Special design aspen crate for gasoline pump.

absorb the product, it is not likely that the output of excelsior in Minnesota will show very great increase. Large supplies of raw material, however, are available.

Crossties

At the present time more than 100,000,000 crossties are used annually in the United States. Altho the crosstie requirements of the country increased rapidly in the early years of railway building they are now declining, and will probably continue to decline to an annual requirement of from 65,000,000 to 75,000,000 crossties. This reduction is almost entirely owing to the use of wood preservatives, better track construction, and more adequate crosstie plating.

Nevertheless, crossties offer a large potential market for a wood that meets the requirements. The records available concerning the service of aspen crossties are encouraging.

To give satisfactory service as a crosstie, a wood must be (1) decay resistant, or made so through preservative treatment, (2) able to resist impact, (3) able to resist spike pulling, and (4) it must be of sufficient strength to withstand the strains of center binding.

There are no simple mechanical tests that can be made of wood to determine its exact value for crossties. Some composite tests to approximate this value, however, have been made by the Forest Products Laboratory. These tests involve (1) static and impact bending, (2) compression parallel to the grain and end hardness, and (3) compression perpendicular to the grain and side hardness. On the basis of these tests, some common crosstie woods were classified. These results are given in Table XI. In the use and interpretation of the data, it must be borne in mind that the figures are approximations and that the mechanical properties of individual pieces of any species may

TABLE XI

Mechanical Properties of Various Species of Wood Used for Crossties

Species	Composite figure
White oak (commercial)	103
Longleaf pine	95
Western larch	80
Douglas fir (coast type)	78
Tamarack	71
Douglas fir (Rocky Mountain type)	65
Jack pine	58
Lodgepole pine	56
Poplar, yellow	55
Largetooth aspen	53
Western red cedar	52
Cottonwood, eastern	49
Aspen	46
Northern white cedar	40

vary as much as 30 per cent either above or below this average value. In Table XI a high composite value is indication of desirable mechanical properties for crosstie purposes.

The composite values indicate that aspen crossties posses mechanical properties somewhat similar to those of northern white cedar, and common cottonwood. Because northern white cedar crossties have given satisfactory service on tangents and switches on lines carrying light traffic, it is reasonable to suppose that aspen ties, properly plated and treated, would give similarly satisfactory service under the same conditions.

Except under very unusual conditions, aspen crossties must be treated with a preservative to give satisfactory service. No data are available giving the life of untreated aspen crossties, but there is reason to believe that under conditions conducive to decay their average life will not be in excess of two or three years. As aspen ties have not been used extensively, few records of service are available.

In 1914, a large Canadian railway system installed a small number of aspen crossties in its tracks near Pembroke, Ontario, where the traffic is not heavy. These crossties were treated with a mixture of creosote-coal tar solution containing 70 per cent creosote and 30 per cent coal tar. The amount of absorption of preservative by these crossties is not stated. At the last inspection, these ties were still giving good service and did not show signs of excessive rail cutting.

In the fall of 1925, the same Canadian railway system let one contract for the delivery of 200,000 aspen crossties in Alberta. Only 45,000 crossties were delivered on this contract because of the prevalence of "black heart" in the aspen from Alberta. At the same time another contract was let for 50,000 crossties. These were delivered, but were also found to contain "black heart." The purchase of aspen crossties by the railway was therefore discontinued, owing entirely to the prevalence of "black heart."

The crossties obtained under these contracts were square sawed, 7 by 9 inches by 8 feet, 7 by 8 inches by 8 feet, and a few were 6 by 7 inches by 8 feet. All crossties were adzed, bored, and incised, and were treated by the "Rueping Process" with a net retention of six pounds of 70-30 creosote-coal tar solution per cubic foot. No difficulty was experienced in making the treatments. The average penetration was about one inch and the distribution of oil in the crossties was uniform. Information is lacking on the treatment of aspen crossties with water soluble preservatives, such as zinc chloride. It is known, however, that aspen fence posts may be rather easily treated with this salt, and there is no apparent reason why aspen crossties should resist treatment with zinc chloride solution.

Altho experience with the use of aspen crossties is limited, it appears that when properly treated they will give satisfactory service when placed in lines over which traffic is not too heavy. It further appears that the greatest obstacle in using aspen for crossties is the prevalence of "black heart," or common heart rot.

If aspen crossties are cut extensively in the Lake States, care must be taken to prevent fungous infection between the time of cutting and treating. Even aspen heartwood is very susceptible to decay. For this reason, it is recommended that aspen crossties be cut during the winter months and seasoned carefully. Preservative treatment should be given as soon as possible after the ties are in proper condition for treatment.

Fuel Wood

It is estimated that 100,000,000 cords of fuel wood are used annually in the United States. Of this amount about 36,000,000 cords are produced on farms. In 1925, about 1,154,000 cords of wood were cut on Minnesota farms; about 1,858,000 cords on Wisconsin farms; and about 1,368,000 cords of fuel wood on Michigan farms.

In all probability only a comparatively small amount of aspen is cut in any of the Lake States for fuel. This, in part at least, is no doubt influenced by the fact that by far the larger stands of aspen are found in the sparsely settled regions of the Lake States. In many respects, aspen makes a good fuel wood. When green, the tree cuts and splits easily, dries out rapidly, and burns with a steady flame. On a weight basis, it gives about as much heat as any other non-resinous wood; that is, a ton of dry aspen yields about as much heat in burning as a ton of hickory or oak. In Table XII are given the fuel values of some common woods. The values are for dry, or comparatively dry woods. The heating value of wood containing larger amounts of moisture is materially reduced and the vigor with which the wood burns is much less. Fire wood should, therefore, be well seasoned before it is used.

On the average, a pound of dry wood liberates on combustion approximately 8,000 B.t.u., bituminous coal 13,000, anthracite coal about 13,000, and charcoal about 16,000 B.t.u. Fuel wood is ordinarily not sold by weight but by volume. A cord of aspen wood will give up on burning only about half the total amount of heat of a cord of white oak or hickory. A cord of dry hickory wood is about equivalent in heating value to a ton of coal, whereas a cord of aspen is about equivalent to one-half ton of coal in heating value.

Even dry wood is, however, a much less concentrated fuel than coal or oil. For this reason, combined with handling costs, it can not be transported long distances and the use of wood as a domestic fuel in urban centers is usually a luxury.

TABLE XII

HEAT VALUES OF CORDWOOD—WEIGHTS FOR OVEN-DRY, AIR-DRY, AND GREEN WOODS, AND ASSUMING 7,350 B.T.U. AVAILABLE PER POUND OF DRY WOOD WITH FLUE GASES AT 300° F.

Species	Available heat units per cord of 90 solid cubic feet (in millions B.t.u.)	
	Air-dry	Green
Hardwoods		
Ash, white (*F. americana*)	20.5	19.9
Aspen, (*P. tremuloides*)	14.1	12.1
Aspen, largetooth (*P. grandidentata*)	14.2	12.4
Basswood, (*T. americana*)	12.6	11.0
Beech, (*F. atropnicea*)	20.9	19.7
Birch, paper (*B. papyrifera*)	18.2	16.7
Birch, yellow (*B. lutea*)	20.9	19.4
Cottonwood, eastern (*P. deltoides*)	15.0	12.7
Maple, sugar (*A. saccharum*)	21.8	20.4
Oak, red (*Q. rubra*)	21.7	19.6
Oak, white (*Q. alba*)	23.9	22.4
Softwoods		
Hemlock, eastern (*T. canadensis*)	15.0	12.8
Pine, jack (*P. divaricata*)	15.7	13.4
Pine, Norway (*P. resinosa*)	17.8	16.8
Coal, long ton (2,240 pounds)	29.1	

* Based on Forest Products Laboratory tests.

Posts

Practically all woods are used for fence posts. A decided preference exists, however, for naturally decay-resistant woods. When these are not available at reasonable prices, posts made of woods lacking natural decay resistance may be used but they should be treated with a preservative. The number of posts required annually in the Lake States is not known, but it probably exceeds 100,000,000. In the United States as a whole, it is estimated that approximately 900,000,000 posts are needed annually.

In Minnesota, aspen fence posts are often used either in their natural condition or treated with a preservative. The average life of an untreated aspen post in the Lake States region is estimated to be from three to six years, depending upon the locality, soil condition, and size of the post. In a semi-arid region aspen posts last much longer.

The average life of creosoted aspen posts is not known. Pressure-treated aspen posts, in tests at the Forest Products Laboratory in co-operation with the University of Wisconsin, were in good condition after thirteen years of service, and will undoubtedly give many more years of service. An estimated average life of 20 to 25 years for properly pressure-creosoted aspen fence posts is thought to be conservative. The posts included in the Wisconsin test absorbed in excess 16 pounds of creosote per cubic foot or approximately two gallons per post. The absorption can be regulated by proper control of the treating conditions. The hot and cold bath process may be used with aspen posts, altho the absorption of the preservative and depth of penetration are not subject to so close control as in pressure treating.

The use of aspen for posts in the Lake States will undoubetdly increase as the more desirable species become scarcer and consequently more expensive. This use probably will have little influence on the general problem, as there are few localities where the production of fence posts forms an industry. More often fence posts are cut by the farmer as the need occurs. Aspen is a common tree in farm woodlots in many sections of the Lake States, and these woodlots will undoubtedly provide a large part of the future demand for fence posts.

Mine Timbers

In 1923, 13,000,000 cubic feet of round, and 20,000,000 board feet of sawed mine timbers were used in the Lake States, principally in Michigan and Minnesota. Altho a comparatively small portion of aspen is used for mine timbers in the Lake States, it is suitable for that purpose. The two outstanding qualifications required of mine timbers are adequate strength and reasonable resistance to decay. Lack of natural decay resistance, however, can be overcome with preservative treatment.

Ordinarily round mine timbers are not graded for either strength or appearance, but in the mining industry there has developed a very definite conception of what species are suitable or at least desirable for the mine timbers. This method of evaluation of the suitability of a species for mine timbers undoubtedly militates against a wider use of aspen for this purpose.

A study of the suitability of different woods for mine timbers has been made by the Forest Products Laboratory, Forest Service, Madison, Wisconsin. The various woods used for mine timbers were classified into five groups based upon a combination of strength properties. These properties are strength as a beam or a post, and toughness or shock resistance. The species were first grouped as to strength as a beam or a post; toughness was then considered and all species ranking low in this property were placed in one group because timbers low in toughness do not give warning of failure.

The average strength of each group is seven eighths of the average of the next higher group. Within each group the species are arranged alphabetically.

The hardwoods listed in Groups I and II are seldom used for mine timbers if other markets are available. This results in the inferior or smaller pieces reaching the mines. Mine timbers of several woods

Group I

Ash, white
Beech
Birch, sweet
Birch, yellow
Douglas fir (dense coast type)
Elm, rock
Larch, western
Maple, red
Maple, sugar
Oak, commercial white
Oak, commercial red
Pine, (dense southern yellow)

Group II

Ash, pumpkin
Cedar, Port Oxford
Cypress, southern
Douglas fir (Rocky Mountain type)
Douglas fir (sound coast type)
Elm, slippery
Elm, American
Gum, black
Gum, tupelo
Gum, red
Hackberry
Hemlock, eastern
Hemlock, western
Magnolia, cucumber
Magnolia (evergreen)
Pine, Norway
Pine, (sound southern yellow)
Tamarack

Group III

Ash, black
Birch, paper
Fir, silver
Fir, noble
Maple, silver
Pine, lodgepole
Pine, northern white
Pine, western white
Spruce, red
Spruce, white
Spruce, Sitka
Sycamore

Group IV

Basswood
Butternut
Cedar, incense
Cedar, western red
Chestnut
Cottonwood, eastern
Fir, white
Pine, jack
Pine, limber
Pine, sugar
Pine, western yellow
Pinon
Poplar, yellow

Group V

Aspen
Buckeye, yellow
Cedar, northern white
Cedar, southern white
Fir, Alpine
Fir, balsam
Spruce, Engelmann
Willow, black

listed in Groups III, IV, and V represent mill or woods run, and consequently show a wide range in strength. The best and strongest material, except for a few species, will not have been sorted for other uses. Sawed mine timbers from Groups III, IV, and V will, therefore, often average better in grade, other things being equal, than those from the Groups I and II. In selecting aspen mine timbers, care must be taken not to include pieces having advanced stages or extensive heart rot. In the storage of aspen mine timbers, precaution must be taken to prevent decay. Removing the bark immediately after cutting and piling to facilitate rapid seasoning will help. As aspen mine timbers are susceptible to decay, unless used temporarily, they should be treated with preservatives.

Slack Cooperage

Aspen has been used to some extent in Minnesota for slack cooperage, particularly for barrels, for the shipment of flour. At the present time there seems to be little or no demand in the Lake States for this type of container and little evidence that it will increase. The cloth sack and the paper bag have almost entirely replaced barrels for the shipment of flour.

Slack cooperage is also used for sugar, fruits, cranberries, candy, chemicals, and other commodities. Quantities of some of these commodities are produced in the Lake States, which suggests that a market may exist for a small amount of slack cooperage. Whether aspen will be used for containers for all of these commodities is doubtful. It is also doubtful if aspen can compete in price with such woods as red gum, elm, and pine. The small size of the aspen trees and the numerous defects prevent its extended use for cooperage purposes. It appears, however, that aspen may compete successfully with other woods for slack cooperage heading. Basswood is generally preferred for this purpose because of its toughness, light color, light weight, and freedom from odor. As heading stock need not be so large as stave stock, no difficulty should be experienced in securing stock for aspen heading that is free from serious defects.

Tight Cooperage

Tight cooperage is extensively used for the shipment of liquids and food substance of various kinds. It is not likely that aspen will be used extensively for this purpose in the Lake States because of its many defects and small size. Aspen may prove satisfactory, however, for the manufacture of certain smaller types of tight cooperage.

Matches

The use of aspen wood in the manufacture of matches in this country is just beginning. The match industry offers a new and large field for the use of aspen after production is on a permanent and large enough scale.

Core Stock

A large amount of furniture is manufactured in the Lake States. Furniture manufacturers are looking more and more for new woods for core stock as the woods they are now using become scarcer and higher in price. The possibility of using aspen for core stock may, therefore, well be considered. Aspen can be delivered to Lake States furniture manufacturers with a comparatively short haul and accompanying low transportation costs.

One of the properties required of wood for core stock is a capacity to take and hold glue. None of the woods extensively used at present and none that have been tested so far excel aspen in this respect. Light weight, ability to stay in place, ease of working, and small shrinkage are additional desirable properties of aspen for core stock. Uniform texture and absence of a tendency of the grain to rise give it an advantage over most soft woods used for this purpose.

Novelties

Because of its physical and mechanical properties, aspen should find favor with industries manufacturing various novelties. Clothespins are manufactured successfully from aspen wood (Fig. 25). There is no reason why aspen could not be used for spools, tongue depressers, swab sticks, skewers, toy stock, and a many other articles. Economic conditions and markets, rather than the technical properties of wood, will probably largely determine the development of these uses of aspen.

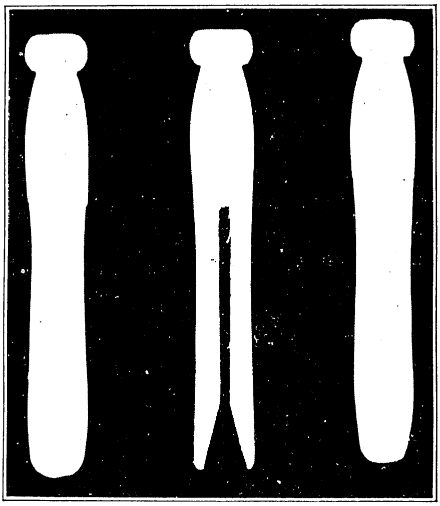

Fig. 25. Aspen Clothespins

Aspen in Pulp and Paper Industry

In 1926 it was estimated that approximately 33,000 cords of aspen pulp wood were used in the entire Lake States. Three years later it was estimated that over 100,000 cords of aspen pulp wood were used in Minnesota alone. Altho this increase may not be general throughout the Lake States, it does indicate that the demand for aspen pulp is increasing.

In Minnesota, the 1930 aspen stumpage prices range from 25 cents to $1 per cord, depending upon the quantity, quality, and accessibility. At the mills, aspen pulp wood brings from $8.50 to $9 per cord of peeled wood. Prices at shipping points are usually equivalent to mill prices less the freight to the mill.

In the Lake States at present, aspen is used extensively for the manufacture of soda pulp. Because of the fact that mills already established in the East are able to supply the existing demand for soda pulp, it is not likely that the production of soda pulp in the Lake States will increase greatly in the immediate future.

Aspen now is used in the sulphite process to produce pulps having specific properties, such as bulk, opacity, and softness. This pulp is used in the manufacture of books, tissue, and specialty papers. There are indications that the output of this type of paper will materially increase. It has been proved by the Forest Products Laboratory that aspen sulphite can be substituted to some extent for spruce and hemlock sulphite, and that it is possible to digest aspen and coniferous woods in the same digester. A small amount of aspen is now ground for newsprint and for pulp boards, and it is possible that this use may increase. Aspen is also used to a small extent in semichemical and semimechanical processes.

On the whole it appears that the future utilization of aspen for pulping depends on its use in the standard pulping methods. These methods will undoubtedly be slightly modified from time to time to produce the kinds of pulp that are most in demand in the paper market. It is believed that large quantities of aspen will eventually be used by the paper industry, thereby giving an important outlet for the vast aspen resources of the region.

Other Uses of Aspen

In addition to the uses previously referred to, aspen has also been used to a small extent for a great variety of products. No detailed information seems to be available concerning the suitability of aspen in the manufacture of these products other than that it has been used. Some of these uses for aspen are:

Baskets, fruit and vegetable packages
Beams and frames for railroad cars
Blocks, brush
Boards, hosiery
Boats, stone
Bodies, vehicle
Bottoms, basket
Boxes and crates
Boxes, bluing
Boxes, butter
Boxes, candy
Boxes, cheese
Box, lock-cornered

Boxes, piano
Boxes, pill
Boxes, shoe peg
Boxes, tackle
Boxes, veneer
Brooms
Brushes
Buckets
Cabinets
Carriers, potato
Carriers, root
Cases, shipping
Casing
Casing, house
Caskets and outside boxes
Ceiling
Clapboards
Cooperage
Crates
Crating
Doors
Dowels and skewers
Dressers
Driers, clothes
Excelsior
Fillers, shoe
Finish, interior, house
Fixtures
Flooring
Forms, hosiery
Forms, shoe
Frames, door
Frames, window
Furniture
Furniture, work, hidden
Games
Handles, brush
Handles, cutlery
Handles, dipper
Handles, knife, oyster
Handles, paint and sweeping
Heads, spool
Hoops, basket
Implements, agricultural
Kegs, putty
Kegs, spice
Kits, fish
Ladders
Lasts, shoe
Lining, interior, refrigerator
Matches
Novelties
Newels, stair
Organs
Pails, candy
Pails, cooky
Parts, body, vehicle, machinery
Parts, organ
Parts, potato machinery
Poles
Products, planing mill
Pulp, paper
Racks, clothes
Refrigerators
Sash, doors, and blinds
Scows, sand
Sheathing
Sheeting
Shingles
Shooks
Shuttles, spools and bobbins
Siding
Sleds, bob
Spools
Stringers
Stringers, clothes rack
Supplies, dispensary
Sweepers, carpet
Tenders, baby
Timbers, mine
Toothpicks
Toys, bottom, cart
Toys, bottom, sled
Toys, bottom, wagon
Toys, game
Toys, wheelbarrow
Toys, yard, play, baby
Trees, show
Tubs, food, poultry
Tubs, jelly
Tubs, lard
Tubs, powder
Tubs, sugar
Vehicle parts
Woodenware
Wool, wood
Work, interior, furniture

Extending the Market for Aspen

Altho aspen may still be regarded as a little-used species, considerable progress has been made in extending its field of usefulness. Aspen has certain characteristics that make it suitable for many uses. The real problem of extending the market for aspen appears to consist largely in acquainting the wood-using industries with the characteristics of the wood and in the recognition of the possibilities for its use.

Industry, however, accepts new woods slowly, and prejudice and custom are difficult to overcome. The most effective way is to accumulate, through research, all the facts dealing with the physical and mechanical properties of the wood. A considerable amount of this work has already been done, but much still remains. The accumulation of facts is not enough. Aspen wood must actually be used for specific purposes, and its suitability for these purposes determined. This type of work has been, and probably will continue to be, done largely by progressive lumber manufacturers.

Wood-using industries should co-operate in these efforts, at least to the extent of maintaining an open mind to the possibilities. Wood-using industries, manufacturing products for which aspen might be suitable might advantageously secure a small shipment of wood and use it in an experimental way. No other single procedure would contribute more towards the rational utilization of wood. New markets for little-used woods are generally mutually advantageous to both the lumber producer and the lumber consumer.

Research agencies and educational institutions can also participate and co-operate in trade extension activities by analyzing the problems confronting the wood-using industries and interpreting their needs in the light of the known facts concerning the properties of various woods. These agencies should at all times be alert to the opportunities to render service to the lumber and wood-using industries and should be so organized and supported that they will be able to respond to the demands made on them.

CONCLUSIONS

The large area of land occupied by aspen forests in the Lake States makes it essential that the species be utilized more extensively. The wood is growing faster than it is being used, and the short life of the tree requires that consumption be more nearly balanced with growth; otherwise large portions of the crop will be wasted.

Aspen is a forest crop from which a profit can be obtained if good judgment is used and the available information is applied to the existing aspen stands.

The clear wood of aspen has many excellent properties. The properties adapt it better to uses where light weight, softness, ease of working, and good gluing and good painting characteristics are desired rather than to uses where great strength and decay resistance are required. The species is better adapted to specialty than to general use requirements.

Regardless of the many excellent properties of the clear wood, uses other than lumber must be relied on for the utilization of the bulk of aspen stands in the Lake States. The small size of the tree and its susceptibility to decay make it difficult to log and mill at a profit. Even under the best of practice the proportion of the higher and profitable grades will be low. The present small production of aspen lumber is therefore due to the size of the tree and yield in grades, and not to inferior properties of the wood.

Dimension stock, that is, stock cut to size at the mill, apparently offers better prospects for marketing aspen at a profit than does yard lumber. The tendency toward the production of dimension stock is increasing. Dimension stock is particularly adapted to the production of small clear pieces in which form aspen is most attractive and it offers a possibility of converting the unprofitable low grades into a more profitable form.

There are good possibilities of marketing aspen at a profit in forms other than lumber. The small size of the tree does not handicap the marketing of the species for pulp wood, excelsior, fence posts, and mine props as it does for lumber. The cost of delivering wood as raw material is much lower than that involved in delivering lumber to users, and the chances of marketing aspen at a profit are therefore better. Recent experiments with new methods of pulping tend to increase its possibilities as a pulp wood. Aspen mixed with eastern hemlock or eastern spruce for the manufacture of sulphite pulp is the most promising possibility for increased utilization of the aspen of the Lake States. Preservative treatment of mine timber and fence posts offer opportunities of increasing the consumption of aspen for these purposes. The Lake States, producing the largest amount of excelsior, offer an excellent market for aspen, especially as it is one of the preferred woods for this purpose. There is, however, small prospect of a material increase in this use.

It is to be expected, therefore, that the bulk of the aspen crop will be marketed as a primary product rather than as lumber.