F, la réduction de vigueur due a la consanguinité, il ne faut utiliser les graines des vergers à graines que si les clones produisent un nuage de pollen suffisant. I1 faut qu'un nombre de clones suffisant produise des fleurs mâles au moment ou les fleurs femelles apparaissent.

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Wood and Pulp Properties as Determined from Slash Pine Increment Core and Whole Tree Measurements

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Introduction

Pulp and paper companies have given active and valuable support to tree improvement work in the United States. Wood quality has become an increasingly important factor in parent tree selection as our knowledge of wood quality-pulp quality relationships. has increased. Evaluation of the wood quality of an individual tree from the papermaking point of view makes it desirable to have information on pulp yield, chernical composition, and paper strength based on standard beater evaluations. The psper strength data most commonly utilized in the evaluation of wood quality are burst, tear, tensile and zero-span tensile strength. The usual procedure is to compare pulp from different trees, areas, or pulp mixtures at one or two common freeness levels (800 and 500 ml. freeness). A direct approach to the evaluation of wood quality of an individual tree would be to cut the tree, pulp it, and measure the pulp yield, the chemical composition, and determine the strength of a paper produced. Such a procedure is costly, time consuming, and from the forest geneticist's point of view has the disadvantage that this results in the loss of the mature tree for breeding work unless, prior to harvest, a number of grafts from this tree have been established.

Another, and more desirable approach, is the use of a nondestructive sampling procedure which produces a wood sample that, first, is representative of the tree ind can be used to measure a number of important physical and chemical wood properties, and second, is large enough to make a small-scale digestion and produce several test sheets for the measurement of a limited number of physical properties. The next step is the use of these limited measurements to predict yield, tear, burst, tensile strength and zero-span tensile strength for the whole tree. The usefulness of such a procedure, of course, hinges on having evaluation methods accurate enough that individual tree differences, when they exist, can be distinguished. This approach is based on the assumption that a portion of the variability encountered in the fundamental wood properties that influence yield, chemical composition, and paper strength are genetically controlled. How strongly these wood properties are inherited can only be determined using controlled crosses, and subsequent evaluation of the progeny using techniques similar to those used to evaluate the parent tree.

Related Studies

Studies of wood property variation in southern pines have been made by a number of workers. The major investigations have been concerned with specific gravity and tracheid length. ZOBEL, et *al.* (1960a) and GOGGANS (1961) present comprehensive reviews that deal in part with recent studies of wood property variation in conifers. The majority of publications report large tree-to-tree variation that is, in many cases, of such magnitude that it tends to overshadow the differences between localities and geographic regions. PERRY and WANG (1958), working with slash pine and ZOBEL, et al. (1960a), working with loblolly pine, reported regional trends in specific gravity. ZOBEL's work also indicated similar but less well-defined regional trends in tracheid length.

Variation in wood properties from the pith outward and from the base to the top make selection of size, number, and location of samples a difficult problern. ECHOLS (1959) suggests that breast height increment samples provide an accurate method of estimating pulp yield and quality. The relation between breast high samples and whole tree values has been studied by MITCHELL (1958), MITCHELL and WHEELER (1959), WAHLGREN and FASSNACHT (1959), and ZOBEL, *et al.* (1960b). WAHLGREN and FASSNACHT, in studying specific gravity of loblolly and slash pine reported correlation coefficients of 0.729 and 0.499 between single breast high increment cores and determinations made on samples representative of the entire tree. ZOBEL, et *al.* reported highly significant correlations between breast high wood samples and total bole values for specific gravity, water-resistant carbohydrates, and alpha-cellulose and considered that breast high samples were suitable for wood quality evaluation work.

The influence of wood properties on pulp and paper properties is of considerable interest to the papermaker and forest geneticists alike. Fiber strength, fiber dimensions,

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and fiber-to-fiber bonding have been considered to be the major factors influencing handsheet strength properties. The work of VAN DEN AKKER, *et al.* (1958) and MACDONNELL and MAY (1959) has demonstrated the important role of intrinsic fiber strength. The importance of fiber-to-fiber bonding was recognized by KEENEY (1952), JAPPE (1958) and MACDONNELL and MAY (1959) in work with slash pine and aspen. A number of other studies, such as that of PILLOW, *et al.* (1941), working with variation in summerwood and compression wood, TAMOLANG and WANGAARD (1961), working with fiber dimensions and fiber strength, DADSWELL, *et al.* (1959), working with cell length, cell-wall thickness, pentosan content, and lignin content and VAN BUIJTENEN, *et al.* (1961a), working with fiber length and specific gravity, have been useful in pointing to the complex interrelationships that exist. The recently published Tappi (1960) Forest Biology Subcommittee 2 Report, presents a comprehensive and valuable review of wood quality-pulp quality relationships.

Research Methods

The trees used in this study consisted of 24 slash pine trees located on Union Bag-Camp Paper Corporation land near Waresboro, Georgia. The trees were a part of a 28 year-old even-aged stand growing on a fairly uniform site. The trees utilized were selected at random by running a line through the stand and using the nearest dominant or co-dominant tree located every 2 chains along the line. Four 10-mm. increment cores were obtained from each tree and these were used to evaluate wood quality.

The per cent summerwood in the core was determined by summing the portions of the core that were composed of summerwood and springwood and then comparing the amount of summerwood with the total length of the core. Next, following the small-scale kraft procedure described by VAN BUIJTENEN, *et al.* (1961), the cores were divided lengthwise into two parts, with 20% of the core being used for chemical determinations and the 80% portion for pulping. Alcohol-benzene extractives and the lignin percentage were determined using the 20% portion and TAPPI Standard Methods T 6 m-54 and T 13 m-54. The remaining 80% portion was broken into sections one-half inch long and was pulped using a small-scale modified kraft cook. The pulping operation was carried out in a battery of 7 digesters which were turned end-over-end in an electrically heated oil bath. This method made it possible to employ a 15-25 g. sample of air-dried chips and pulp 7 trees at the same time. A more detailed description of the equipment and procedure used are given by VAN BUIJTENEN, *et al.* (1961b) and THODE, *et al.* (1961).

TAPPI Standard handsheets were prepared from the pulp produced by the individual tree "microcook" and information on yield, permanganate number, basis weight, caliper, apparent density, zero-span tensile strength, fiber length, and formation were determined on the pulp and/or handsheets. The zero-span tensile strength values were determined according to the procedure described by WINK and VAN EPEREN (1961) and are interpreted as a measure of inherent fiber strength. The average fiber length was determined by taking a small sample of the pulp and measuring a total of 300 fibers.[2])

[2]) Fiber measurements were made on intact, broken, and cut fibers alike and this, of course, results in values lower than have been reported by other investigators working with intact slash pine tracheids.

The second phase of this study consisted of obtaining representative wood samples from the 24 trees by felling and bucking them into 30-inch bolts. Every third bolt was selected for further study, bolt no. 1 being located at the 24—54 inch level above the ground. One-inch disks were taken from the lower end of each of the selected bolts and a breast high[3]) (b. h.) disk was obtained by sampling the top of bolt no. 1. The disks were kept moist and used to obtain information on whole tree (W. T.) specific gravity, per cent summerwood, per cent heartwood, per cent compression wood, and per cent juvenile wood. The selected bolts were chipped and the chips from all bolts of the same tree were combined and thoroughly mixed to form a composite sample. From this composite sample digester charges of equal weight were removed and bagged. Representative samples removed during the bagging operation were weighed, oven dried, and reweighed to provide chip moisture information.

A kraft cook using a modified one cubic foot digester was employed in pulping the chip samples. The digester was modified so that chips from four trees could be run at the same time acording to the procedures of THODE, *et al.* (1961). Random numbers were used in selecting the four chip samples (trees) that were to be cooked together. Duplicate cooks were made on each tree. *Table 1* lists the cooking conditions employed in this study. Permanganate number and yield were determined on each cook and the TAPPI Standard beater evaluation performed on each of the duplicate cooks. The handsheet tests made included zero-span tensile strength, tensile strength, stretch, energy to rupture, tear factor, bursting strength, formation, caliper, and apparent density.

Table 1. — Cooking Conditions.

Slash Pine Whole Tree Pulping Study	
Max. temp., °C.	170
Time to 170° C., min.	105
Time at 170° C., min.	135
Blowdown to 50 p. s. i., min.	10
Liquor-to-wood ratio	6.0
Liquor concn., g./l. as NaOH	40.0
Sulfidity, %	25.0

Chemical analyses on representative wood samples from each tree included alcohol-benzene extractives and per cent lignin. Fiber length was determined on the unbeaten pulp by measuring 900 fibers. The fibers were obtained by using equal amounts of pulp from each of the two cooks on a tree and making up slides from this composite sample. The fibers were measured on a semiautomatic recording, fiber-measuring apparatus of Finnish manufacture. The fiber length values reported are the weighted average fiber length. Standard Institute methods employed by the Fiber Microscopy Section were used in making up the slides, recording the data, and computing the weighted average fiber length.

Results

Summary of Data

A large amount of data was collected on the 24 trees used in the two phases of this study. For the sake of clarity and ease of discussion the results have been subdivided into the following topics: Summary of data, preliminary analyses, increment core-whole tree wood property correlations,

[3]) Breast high (b. h.) indicates samples taken at 54 inches above the ground.

increment core-whole tree pulp property correlations, whole tree wood-whole tree pulp property correlations, and multiple correlations using increment core data.

The wood and pulp quality measurements based on increment cores and collected in the first phase of this study, are presented in *Table 2*. *Table 3* summarizes the whole tree wood property data that were obtained using the disks located every 90 inches along the stem of the tree and/or representative chip samples from the whole tree. The whole tree fiber length information presented is based on measurements taken on the unbeaten pulp. The per cent summerwood, the per cent compression wood, and the per cent heartwood are the weighted values for the entire tree. Juvenile wood and specific gravity information is given for both b. h. samples and weighted values for the entire tree. Included also are the averages and the standard deviations of the properties measured.

A summary of the results of the standard TAPPI beater

Table 2. — Slash Pine Wood and Pulp Properties — Data Obtained from Breast Height Increment Cores.

Tree No.	Alcohol-Benzene Extractives, %	Lignin, %	Yield Corrected for Extractives, %	Permanganate Number	Yield, %	Basis Weight	Caliper	Apparent Density	Zero-span Tensile Strength, lb./in.	Summerwood, %	Average Fiber Length, mm.	Thwing Formation, units
30—1	8.6	28.0	44.5	24.8	40.7	45.7	6.3	7.3	55.7	56	2.58	26.0
—2	6.1	29.1	43.0	20.8	40.4	47.4	6.6	7.2	58.3	57	2.63	32.9
—3	6.9	29.0	44.6	23.4	41.5	46.2	6.3	7.3	40.9	53	2.38	37.3
—4	7.8	28.6	42.5	20.8	39.2	46.4	6.3	7.4	52.3	56	2.29	37.3
—5	5.6	27.3	44.6	19.5	42.1	46.4	6.4	7.2	55.7	59	2.49	39.7
—6	7.15	28.8	41.9	18.0	38.9	47.8	5.9	8.1	50.8	52	2.21	47.2
—7	11.15	28.6	44.9	22.0	39.9	47.4	6.6	7.2	64.4	46	2.65	36.8
—8	3.9	27.3	45.8	21.1	44.0	44.0	5.6	7.9	52.1	54	2.34	37.3
31—1	5.8	26.2	45.1	18.3	42.5	46.1	6.0	7.7	55.8	52	2.80	33.3
—2	8.2	27.0	45.3	18.8	41.6	47.7	6.1	7.8	53.9	52	2.46	36.2
—3	6.2	27.9	43.9	19.8	41.2	46.3	5.8	8.0	51.6	52	2.60	35.7
—4	5.65	28.5	42.6	18.8	40.2	47.3	6.6	7.2	61.1	45	2.69	35.2
—5	6.6	29.3	44.9	20.0	41.9	47.9	6.5	7.4	58.7	50	2.77	36.8
—6	6.1	27.6	44.8	19.8	42.1	46.6	6.6	7.1	55.3	51	2.63	35.2
—7	13.5	28.2	44.3	17.8	38.3	46.1	6.4	7.2	55.4	56	2.40	39.1
—8	4.4	28.0	43.7	17.9	41.8	46.8	6.3	7.4	68.3	48	2.51	34.7
37—1	10.4	27.3	42.5	16.6	38.1	46.2	6.2	7.4	54.3	43	2.50	41.7
—2	6.2	26.9	44.9	16.7	42.1	48.9	7.0	7.0	58.1	47	2.74	37.3
—3	6.35	28.2	45.1	22.5	42.2	47.5	6.7	7.1	49.0	50	2.21	35.7
—4	6.1	28.0	44.8	21.3	42.1	45.8	6.5	7.0	59.6	52	2.65	30.5
—5	8.5	28.4	44.0	18.7	40.3	46.9	6.1	7.7	53.9	59	2.60	37.9
—6	7.7	28.4	44.6	20.1	41.2	47.3	6.1	7.8	49,4	53	2.27	45.5
—7	11.8	27.9	46.7	21.6	41.2	48.7	7.5	6.5	45.7	52	2.11	34.7
—8	6.2	30.0	43.7	22.7	41.0	46.9	6.2	7.6	39.5	59	2.29	37.9
Average	7.4	28.1	44.3	20.1	41.0	46.8	6.4	7.4	54.2	52.2	2.49	36.7
Standard deviation	2.3	.83	1.11	2.10	1.38	1.04	.40	.36	6.4	4.3	.19	4.2

Table 3. — Slash Pine Whole Tree Wood and Chemical Properties.

Tree No.	Summerwood, %	Compression Wood, %	Juvenile Wood from b. h. Disks, %	Juvenile Wood from Whole Tree, %	Specific Gravity Detd. from b. h. Disks, g./cc.	Specific Gravity Detd. from Whole Tree, g./cc.	Weighted Average Fiber Length Detd. from Pulp, mm	Heartwood, %	Lignin, %	Unscreened Yield, %	Alcohol-Benzene Extractives, %
30—1	38.8	77	9	19	0.671	0.576	3.05	5.3	28.3	46.9	4.3
—2	42.0	39	27	24	0.609	0.551	2.89	3.6	27.9	48.3	5.1
—3	42.7	40	12	16	0.640	0.557	2.65	4.9	28.8	46.8	4.8
—4	42.5	24	31	23	0.608	0.529	2.64	2.1	27.7	48.2	3.5
—5	41.1	33	18	16	0.612	0.546	2.54	2.6	27.8	47.7	2.8
—6	39.9	15	20	27	0.602	0.517	2.75	5.2	27.8	47.5	4.7
—7	31.2	40	21	23	0.599	0.522	2.75	4.9	28.5	46.0	4.9
—8	39.4	39	22	22	0.646	0.572	2.71	3.8	27.3	48.6	3.1
31—1	33.8	30	10	22	0.601	0.549	2.93	7.1	26.3	48.6	3.8
—2	31.9	15	7	14	0.544	0.508	3.08	7.2	27.1	48.0	4.8
—3	36.9	38	19	21	0.560	0.503	3.20	3.3	27.5	46.5	4.0
—4	31.7	26	8	13	0.490	0.469	2.83	4.3	28.3	48.4	3.6
—5	38.2	20	38	27	0.579	0.540	3.19	4.9	28.2	48.2	2.7
—6	40.2	16	27	20	0.597	0.559	2.90	2.4	27.3	50.3	3.8
—7	48.5	59	28	22	0.595	0.558	3.02	3.0	28.1	48.3	5.3
—8	36.0	00	13	26	0.574	0.536	3.08	4.5	27.7	46.2	3.5
37—1	35.9	25	13	19	0.572	0.496	3.18	7.2	27.3	47.3	5.3
—2	35.0	40	13	21	0.555	0.521	3.09	1.7	27.2	48.2	3.2
—3	37.7	39	20	22	0.618	0.583	2.72	8.7	28.1	48.2	4.5
—4	38.6	21	19	23	0.594	0.530	3.21	2.9	26.6	48.2	3.7
—5	43.3	56	21	21	0.596	0.547	2.93	3.4	27.8	47.4	4.5
—6	35.8	90	10	19	0.583	0.513	2.61	5.9	27.7	47.0	4.7
—7	42.1	27	39	32	0.544	0.569	2.81	6.5	27.1	49.0	4.7
—8	43.1	40	13	14	0.628	0.570	3.03	5.3	28.4	47.2	2.8
Average	38.6	35	19	21	0.592	0.539	2.91	4.6	27.7	47.8	4.1
Standard deviation	4.17	19.5	9	4	0.037	0.028	0.20	1.8	0.59	0.94	0.80

Table 4. — Slash Pine Standard TAPPI Beater Evaluation Data — Average Values of Duplicate Cooks.

Tree No.	Handsheet Properties at 800 cc. Bursting Strength, pt./100 lb.	Tear Factor	Tensile Strength, lb./in.	Energy to Rupture, in. lb./ sq. in.	Stretch, %	Apparent Density, g./cc.	Handsheet Properties at 500 cc. Bursting Strength, pt./100 lb.	Tear Factor	Tensile Strength, lb./in.	Energy to Rupture, in. lb./ sq. in.	Stretch, %	Apparent Density, g./cc.	Zero-Span Tensile Strength, lb./in.	Unscreened Yield, %	Permanganate No.
30—1	120	2.70	32.5	0.574	2.60	11.4	146	1.99	36.4	0.736	2.90	12.6	59.25	46.9	23.8
—2	118	2.43	30.0	0.540	2.65	11.5	140	2.00	34.6	0.710	3.00	12.6	60.35	48.3	24.4
—3	106	2.60	26.6	0.595	3.10	12.2	126	2.02	30.5	0.700	3.15	13.4	54.25	46.8	25.5
—4	118	2.58	30.2	0.562	2.65	11.6	137	2.14	34.8	0.702	3.00	12.4	60.20	48.2	24.1
—5	110	2.38	29.8	0.510	2.35	11.4	134	1.96	33.8	0.628	2.70	12.8	55.40	47.7	23.2
—6	131	2.30	31.9	0.660	3.00	12.4	142	1.92	35.2	0.734	3.10	13.4	59.15	47.5	23.4
—7	126	2.26	33.0	0.555	2.55	11.8	154	1.86	37.8	0.744	2.95	12.9	64.00	46.0	21.8
—8	118	2.55	29.8	0.609	2.95	12.2	138	2.11	33.4	0.771	3.20	12.8	51.50	48.6	23.6
31—1	118	2.44	30.4	0.469	2.55	11.3	143	1.94	34.8	0.681	2.90	12.6	59.95	48.6	22.3
—2	133	2.26	34.0	0.598	2.60	11.8	154	1.87	37.6	0.749	2.80	12.6	57.10	48.0	23.2
—3	117	2.37	30.6	0.580	2.60	11.8	136	1.92	34.7	0.660	2.60	12.7	60.20	46.5	22.6
—4	131	2.22	33.7	0.586	2.55	11.8	152	1.74	38.3	0.714	2.70	12.6	62.25	48.4	24.1
—5	124	2.62	31.5	0.608	2.75	11.8	144	2.10	35.8	0.738	3.00	12.5	61.25	48.2	22.6
—6	114	2.74	29.2	0.550	2.70	11.4	140	2.15	34.7	0.715	3.00	12.8	59.80	50.3	24.0
—7	123	2.33	31.0	0.635	3.00	12.4	143	1.88	35.0	0.778	3.15	13.3	51.60	48.4	22.2
—8	130	2.52	35.2	0.580	2.55	11.8	154	2.02	38.6	0.712	2.85	12.6	65.00	46.2	22.1
37—1	134	2.36	32.1	0.678	2.85	12.5	152	1.91	36.6	0.779	3.05	13.3	59.60	47.3	24.6
—2	124	2.21	32.0	0.602	2.80	11.8	142	1.77	35.3	0.708	2.95	13.0	56.60	48.2	22.5
—3	119	2.26	29.3	0.569	2.80	11.9	139	1.76	34.0	0.728	3.05	13.2	56.65	48.2	25.5
—4	120	2.56	30.8	0.550	2.55	11.6	142	1.95	35.8	0.689	2.75	12.6	59.85	48.2	24.4
—5	124	2.38	30.2	0.639	3.10	12.2	142	2.03	33.4	0.742	3.15	13.3	56.40	47.4	23.4
—6	119	2.22	29.5	0.641	3.10	13.2	136	1.82	33.6	0.730	3.25	13.8	52.60	47.0	24.5
—7	104	2.88	27.4	0.502	2.50	11.2	125	2.24	32.6	0.660	2.90	12.4	54.65	49.0	24.4
—8	120	2.68	30.1	0.634	3.05	12.0	132	2.15	33.6	0.742	3.15	13.1	55.20	47.2	23.8
Average	121	2.45	30.9	0.584	2.75	11.9	141	1.97	35.0	0.719	2.97	12.9	58.03	47.8	23.6
Standard deviation	7.6	0.18	1.94	0.157	0.22	0.45	7.9	0.13	1.85	0.115	0.17	0.37	3.56	0.95	1.0

evaluations made on the whole tree pulps are presented in *Table 4*. These data consist of the average values obtained from the duplicate cooks made on each tree. Statistically, the basic beater evaluation data from which *Table 4* was derived, are important and were used in certain phases of the statistical analyses. These basic data, although not included in this paper, will be discussed in the section on preliminary analyses.

Of basic interest in this study are the correlations that exist between the information that can be obtained on increment core samples and similar measurements made on disks or chip samples representative of the entire tree. Also of importance is the establishment of the usefulness of increment core data in predicting important paper strength properties (tear, burst, tensile strength, and zero-span tensile strength), that are vital for proper evaluation of a tree from the wood quality point of view. The results of the simple and multiple correlation calculations are presented in *Tables 5* through *11*.

Preliminary Analyses

The first step in the preliminary analyses was the running of the analysis of variance on a portion of the basic data obtained from the duplicate cooks made on the whole tree chip samples. The data used in these calculations included tear, burst, tensile strength, and stretch, each at 800-ml. freeness, and zero-span tensile strength. The results of these calculations indicate that there was no significant difference between the values obtained from the duplicate cooks on each tree and that average values for the cooks presented in *Table 4* could be used in the simple and multiple correlations that were to be calculated.

A summary of the analyses of variance obtained is presented in *Table 5*. The outcome of the analyses is of interest because "*F*" tests indicate that there were highly significant differences between trees in stretch, tear, burst, and tensile strength. Only the "*F*" test on zero-span tensile strength failed to show significant differences between trees.

Table 5. — Analysis of Variance, Handsheet Properties.

Source of Variation	Degrees of Freedom	Tear — 800 cc. Sum of Squares	Tear — 800 cc. Mean Square	Tear — 800 cc. $F^{a)}$	Burst — 800 cc. Sum of Squares	Burst — 800 cc. Mean Square	Burst — 800 cc. $F^{a)}$	Tensile — 800 cc. Sum of Squares	Tensile — 800 cc. Mean Square	Tensile — 800 cc. $F^{a)}$
Total	47	1.853	—		3090	—		196.1	—	
Cooks	1	0.0032	0.0032	0.314	0.0208	0.0208	0.001	0.0352	0.0352	0.058
Trees	23	1.617	0.0732	6.97	2768	120.4	8.61	182.2	7.920	13.1
Error	23	0.2322	0.0101		321.4	13.98		13.88	0 6035	
		Stretch — 800 cc.			**Zero-Span Tensile**					
Total	47	2.619	—		971.4	—				
Cooks	1	0.0300	0.0300	2.38	35.02	35.02	2.45			
Trees	23	2.299	0.0999	7.93	608.2	26.45	1.85			
Error	23	0.2899	0.0126		328.2	14.26				

a) $F_{.01(23,23)} = 2.70$; $F_{.05(23,23)} = 2.03$

$F_{.05(1,23)} = 4.28$

Table 6. — Summary of Significant Increment Core — Whole Tree Wood Property Correlations.

Variables			Correlation Coefficients[a)]
Fiber length, core	—	Fiber length, W. T.[b)]	+ 0.499
Fiber length, core	—	Summerwood %, W. T.	— 0.412
Specific gravity, b. h. wedge	—	Specific gravity, W. T.	+ 0.730
Specific gravity, b. h. wedge	—	Summerwood %, core	+ 0.556
Specific gravity, b. h. wedge	—	Summerwood %, W. T.	+ 0.463
Summerwood %, core	—	Summerwood %, W. T.	+ 0.710
Summerwood %, core	—	Specific gravity, W. T.	+ 0.558
Summerwood %, W. T.	—	Specific gravity, W. T.	+ 0.594
Lignin %, core	—	Lignin %, W. T.	+ 0.752
Extractives %, core	—	Extractive %, W. T.	+ 0.668
Yield %, core	—	Yield %, W. T.	+ 0.257[c)]
Yield %, core	—	Specific gravity, W. T.	+ 0.506

a) $r_{.01} = .515$; $r_{.05} = .404$.
b) Measurements based on samples representative of the whole tree.
c) Not significant, presented for comparison purposes.

Increment Core and Whole Tree Wood Property Correlations

Simple correlations were run as one step in evaluating the usefulness of 10-mm. b. h. increment cores in estimating whole tree wood quality. The properties selected for this comparison included fiber length, specific gravity, and the percentages of summerwood, yield, lignin, and alcohol-benzene extractives. Information on these variables was obtained both on the increment core samples and wood and/or chip samples representative of the entire tree. Correlation coefficients were obtained for all possible combinations of the variables. *Table 6* summarizes the significant correlations that resulted from the calculations. The simple correlation of increment core yield corrected for extractives and whole tree (W. T.) yield was the only nonsignificant correlation included in *Table 6*. Based on the calculated correlation coefficients described above, it appears that satisfactory whole tree estimates can be obtained for the per cent extractives, per cent lignin, and per cent summerwood by using increment core samples taken at b. h. Similarly, a highly significant correlation was obtained between b. h. specific gravity samples and W. T. specific gravity values.

The simple correlation was also calculated using the percentage juvenile wood measured on a. b. h. disk and the W. T. weighted average per cent juvenile wood. The results of the simple correlation calculations gave a highly significant "*r*" value of .725. This indicates that an estimate of W. T. per cent juvenile wood can be obtained from b. h. increment core samples.

The increment core fiber length, and whole tree fiber length correlation, although significant at a little below the 1% level, is not as well correlated as is desirable. There are several facets to this problem. The difficulty seems in part to stem from the large variability in fiber lengths in the whole tree pulp sample and in part from the increased sampling problem that arises from the larger pulp sample provided by the whole tree pulping procedure. Increasing the number of fibers measured from 300 to 900[4]) compensated for the large variation in fiber length and greatly improved the accuracy of the pulp fiber length measurements. Examination of the data indicates that further improvement in this correlation could be made by measuring still larger numbers of fibers on both the cores and the whole tree pulp and also by making some minor modification in the sampling procedure.

[4]) Three hundred fibers were measured on the increment core fiber length samples while a total of 900 fibers were measured on the whole tree pulp samples.

The increment core-whole tree pulp yield correlation was the only comparison of this type that was not significant. Examination of the data indicates that the lack of correlation may have resulted for several reasons. The possibility that seems most likely is that the differences in the whole tree yield found in this stand were too small to be detected by b. h. increment core sampling. Most of the additional significant correlations listed in *Table 6*, particularly those involving summerwood per cent and specific gravity measurements follow a logical pattern. Worthy of mention is the lack of correlation between yield of pulp and specific gravity. This is not surprising when it is remembered that yields are calculated on a weight basis and not on a volume basis.

Increment Cores — Whole Tree Pulp Property Correlations

Another important aspect of this study is the comparison of increment core data with pulp handsheet strength data determined by pulping representative samples of whole trees. The increment core measurements used in these comparisons are the same as used in the previously described correlations and include specific gravity, zero-span tensile strength, fiber length, extractives, summerwood per cent, and lignin per cent.

The whole tree handsheet properties used included tear, burst, tensile strength, zero-span tensile strength, and stretch. Measurements were based on 24 trees and the strength data compiled at both 500- and 800-ml. freeness levels using the average values *(Table 4)* of the duplicate cooks. Simple correlations were run on all possible combinations of the above data. Only those correlations that were significant and/or pertinent to this study are reported in *Table 7*.

Examination of the correlations in *Table 7* are helpful in selecting the increment core data that is most useful in estimating pulp quality. Zero-span data taken on increment cores seem to be the variable that provides the most information on handsheet strength properties. Zero-span of the core was correlated positively with zero-span of the pulp, burst at 500- and 800-ml. freeness, tensile at 500- and 800-ml. freeness, and negatively correlated with stretch at 500- and 800-ml. freeness.[5]) Fiber length of the core was also

[5]) Levels of significance can be obtained by using *Table 7* "*r* values" and the footnote *a* of *Table 7*.

Table 7. — Summary of Increment Core — Whole Tree Handsheet Property Correlations.

Variables		Correlation Coefficients a) 800 cc.	500 cc.
Specific gravity, b. h.	Tensile	— 0.372	— 0.444
	Stretch	+ 0.300	— 0.469
	Tear	+ 0.353	+ 0.335
Zero-Span, core	Zero-span, pulp b)	+ 0.670	
	Burst	+ 0.504	+ 0.774
	Tensile	+ 0.727	+ 0.793
	Stretch	— 0.537	— 0.438
Fiber length, core	Zero-span, core b)	+ 0.653	
	Zero-span, pulp b)	+ 0.541	
	Burst	+ 0.259	+ 0.495
	Tensile	+ 0.403	+ 0.448
	Stretch	— 0.361	— 0.430
Summerwood, core	Zero-span, core b)	— 0.424	
	Zero-span, pulp b)	— 0.487	
	Tear	+ 0.312	+ 0.440
	Tensile	— 0.443	— 0.554
	Burst	— 0.473	— 0.542

a) $r_{.01} = .515$, $r_{.05} = .404$

b) Zero-span measurements for cores were not taken at 800 cc. but were taken on lightly beaten handsheets. Similarly, zero-span on pulp was the average value for handsheets beaten for 5, 15, 30, 50 minute intervals.

negatively correlated with stretch at 800-ml. freeness and was correlated positively with tensile strength and burst at the lower freeness level. Fiber length also shows a highly significant correlation with zero-span of the core and zero-span of the whole tree pulp.

The per cent summerwood of the core and specific gravity taken on b. h. wedges were also correlated with several paper strength properties. The per cent summerwood followed a consistent pattern, being positively correlated with tear (500-ml. freeness level and 5% probability level) and negatively correlated with burst, tensile strength and zero-span tensile strength.

Tear was the handsheet property that was correlated least with increment core measurements. Tear followed a trend much as might be expected being positively correlated with specific gravity (not significant at the 5% level) and per cent summerwood but significantly correlated only at the 500-ml. freeness level with per cent summerwood. Increment core data pertaining to lignin and alcohol-benzene extractives were not found to be significantly correlated with handsheet strength properties and the commonly accepted positive correlation between tear and fiber length was not encountered in this data.

Whole Tree Wood — Whole Tree Pulp and Paper Property Correlations

The third group of comparisons of basic interest to geneticists and paper technologists alike are those involving wood and paper strength data obtained from representative samples of entire trees. The wood property variables utilized in this comparison included fiber length, juvenile wood per cent, specific gravity, summerwood per cent, and the percentage of compression wood. The whole tree pulp handsheet strength data used in these comparisons included burst, tear, tensile strength, apparent density, and stretch values measured at 500- and 800-ml. freeness. Included also were zero-span tensile strength and permanganate number measured on whole tree pulp samples.

Simple correlations were calculated between the variables involved and were used as a basis for discussing certain relationships that exist between the variables. The number of correlation coefficients which result from the calculations is very large and it is again necessary to list only those correlations which are significant and/or pertinent to this portion of the Results section. *Table 8* presents the results of these calculations.

Table 8. — Significant Whole Tree Wood and Whole Tree Pulp and Paper Property Correlations at 800- and 500-ml. Freeness Levels.

Variables		Correlation Coefficients a) 800 ml.	500 ml.
Fiber length	Burst	+ 0.432	+ 0.414
Permanganate no.	Burst	— 0.348 b)	— 0.454
Specific gravity	Burst	— 0.598	— 0.502
Zero-span tensile	Burst	+ 0.428	+ 0.606
Tear factor	Burst	— 0.566	— 0.474
Tensile strength	Burst	+ 0.865	+ 0.924
Summerwood, %	Burst	— 0.485	— 0.616
Specific gravity	Tear	+ 0.597	+ 0.518
Summerwood, %	Tear	+ 0.458	+ 0.537
Tensile strength	Tear	— 0.420	— 0.393 b)
Apparent density	Tear	— 0.472	— 0.367 b)
Fiber length	Tensile	+ 0.455	+ 0.449
Permanganate no.	Tensile	— 0.563	— 0.481
Specific gravity	Tensile	— 0.537	— 0.544
Zero-span tensile	Tensile	+ 0.598	+ 0.713
Stretch	Tensile	— 0.310 b)	— 0.470
Summerwood, %	Tensile	— 0.579	— 0.631
Zero-span tensile	Apparent density	— 0.411	— 0.493
Stretch	Apparent density	+ 0.795	+ 0.661
Compression wood	Apparent density	+ 0.418	+ 0.499
Zero-span tensile	Stretch	— 0.559	— 0.527
Summerwood, %	Stretch	+ 0.402	+ 0.431
Compression wood	Stretch	+ 0.423	+ 0.407
Specific gravity	Summerwood, %	+ 0.594	
Zero-span tensile	Summerwood, %	— 0.518	
Zero-span tensile	Compression wood	— 0.523	
Zero-span tensile	Specific gravity	— 0.407	

a) Correlation coefficient of the wood and pulp and/or paper properties at 500- and 800-ml. Schopper-Riegler freeness levels, $r_{.05} = .404$, $r_{.01} = .515$

b) Nonsignificant correlations listed for comparison purposes.

Burst was found to be positively correlated with whole tree data on fiber length, zero-span tensile strength and tensile strength at both 500- and 800-ml. freeness levels. Burst was negatively correlated with permanganate number, specific gravity, tear, and summerwood per cent.

Tensile strength and burst are highly correlated at both freeness levels ($r = 0.924$ and $r = 0.865$) and tensile strength has a pattern of correlation very similar to that of burst. Tensile strength, as in the case of burst, was found to be positively correlated with fiber length and zero-span tensile strength at both levels of freeness. Tensile strength, like burst, was found to be negatively correlated with permanganate number, specific gravity, and per cent summerwood at both freeness levels. Only in the case of the negative correlation between tensile strength and stretch at 500-ml. freeness did the correlation pattern differ.

Tear was not correlated with as many whole tree wood or pulp handsheet properties as burst and tensile strength. Tear was found to be positively correlated with specific gravity and per cent summerwood and negatively correlated with burst, tensile strength and apparent density. The correlations with tensile strength and apparent density were significant only at the 5% level of probability and only at the 800-ml. freeness level. Other correlations that merit mention were those with zero-span tensile strength. Zero-span tensile strength was positively correlated with burst and tensile strength and negatively correlated with stretch, apparent density, specific gravity, per cent summerwood, and per cent compression wood.

Multiple Correlations Using Increment Core Data

The strength properties of a paper influence its usefulness as a commercial product and are a function of a number of raw material and processing variables. Because of the complex and interrelated nature of these variables, it is not surprising that the use of a single factor such as fiber length does not provide an adequate method of predicting paper strength. The proper approach seems to be to use several independent variables to predict paper strength properties.

The techniques of multiple regression and multiple correlation, SNEDECOR (1956), are very useful in making such calculations. To investigate the possibility of using increment core data in predicting handsheet strength properties, multiple correlations of handsheet strength properties on selected increment core variables were calculated. The data used included the strength property information obtained from the whole tree pulping work *(Table 4)* and the increment core data collected in the first phase of this study *(Table 2)*. Used also was the specific gravity information obtained from b. h. samples and per cent juvenile wood based upon whole tree measurements. These data were treated as though they were increment core data because it was felt that this information could be adequately determined from increment core samples.

Table 9. — Multiple Regression of Tensile Strength at 500- and 800-ml. Freeness on a Number of Selected Variables.

Independent Variables	Partial Standard Regression Coefficients	
	500 ml.	800 ml.
Zero-span tensile, core	+ 0.949	+ 0.937
Fiber length, core	— 0.265	— 0.297
Specific gravity, b. h. wedges	— 0.212	— 0.140
Juvenile wood %, whole tree	— 0.277	— 0.338
Multiple correlation coefficient a)	0.863	0.809

a) $R_{.01} = .698$ is 'R' value required to be significant at the 1% level.

Table 9 summarizes the multiple correlation and standard partial regression coefficients calculated for tensile strength at 500- and 800-ml. freeness.[6]) Zero-span tensile strength fiber length, specific gravity, and per cent juvenile wood were the variables used to predict the tensile strength at 500- and 800-ml. freeness. The multiple correlation coefficients at both 500- and 800-ml. freeness levels were highly significant, and indicate good agreement between the predicted and actual tensile strength at both freeness levels. Using the standard partial regression coefficient as a guide, it becomes evident that zero-span tensile strength was the independent variable which contributed most to the success of the prediction. The negative regression coefficient of fiber length is interesting because it must be interpreted to mean that if all other independent variables are held constant, tensile strength decreases with increasing fiber length. Analogous interpretations must also be made for the negative regression coefficients associated with specific gravity and per cent juvenile wood.

[6]) The orthogonal nature of the data was checked by calculating the multiple correlation and standard partial regression coefficients several times using different orders of input of the independent variables.

Table 10. — Multiple Regression of Bursting Strength at 500- and 800-ml. Freeness on a Number of Selected Variables.

Independent Variables	Partial Standard Regression Coefficient	
	500 ml	800 ml
Zero-span tensile, core	+ 0.930	+ 0.680
Fiber length, core	— 0.174	— 0.275
Specific gravity, b. h. wedges	— 0.069	— 0.210
Juvenile wood, %, whole tree	— 0.326	— 0.318
Multiple correlation coefficient a)	0.834	0.628

a) $R_{.05} = .615$ $R_{.01} = .698$ are the 'R' values required to be significant at the 5 and 1% level.

Table 10 summarizes the multiple correlation and standard partial regression coefficient calculations for the whole tree bursting strength at 500- and 800-ml. freeness on four independent variables.[6]) Zero-span tensile strength, fiber length, specific gravity, and per cent juvenile wood were the increment core variables used. The multiple correlation coefficients for bursting strength at 500-ml. freeness ($R = .834$) was highly significant and indicates very good agreement between the predicted and actual bursting strength. The multiple correlation for the 800-ml. freeness level ($R = .628$) was significant at the 5% level and indicates that the independent variables were less successful in predicting the whole tree bursting strength. Better formation and fiber-to-fiber bonding at 500-ml. freeness level may in part account for the improved multiple correlation obtained.

Zero-span tensile strength based on the standard partial regression coefficient, accounts for a large part of the predictable variation. The per cent juvenile wood also has a strong influence on the bursting strength. The negative standard partial regression coefficient associated with the juvenile wood per cent must be interpreted as meaning that increasing the amount of juvenile wood results in a decreased bursting strength.

The multiple correlation and the standard partial regression coefficients were calculated for tear factor using the independent variables of zero-span tensile strength, fiber length, specific gravity, and juvenile wood per cent.

Table 11. — Multiple Regression of Tear Factor at 500- and 800-ml. Freeness on a Number of Selected Variables.

	Standard Partial Regression Coefficient	
	500 ml.	800 ml.
Zero-span tensile, core	— 0.447	— 0.477
Fiber length, core	+ 0.171	+ 0.270
Specific gravity, b. h. wedge	+ 0.224	+ 0.245
Juvenile wood, %, whole tree	+ 0.475	+ 0.446
Multiple correlation coefficient a)	0.587	0.564

a) $R_{.05} = 0.615$

Table 11 summarizes the correlation and regression coefficients obtained at both freeness levels. The results of these calculations indicate that tear factor is not adequately predicted by the increment core variables used although at the 500-ml. freeness level the multiple correlation approaches the 5% level of significance. Examination of the standard partial regression coefficients indicate that the per cent juvenile wood and the zero-span tensile strength account for the major portion of the predictable variation. Zero-span tensile strength was found to be negatively related to the tear factor. Here again, bonding seems to be the variable that is not adequately accounted for by the increment core data.

Preliminary correlations indicated that the accuracy of tear prediction could be improved if the per cent compression wood was included as one of the variables. This variable was added and the multiple correlations rerun. Results of this second calculation indicate that if, in addition to zero span tensile strength fiber length, specific gravity and juvenile wood, a good estimate of compression wood were available, a reasonable estimate of tear could be obtained from increment core data.

Multiple correlation and standard partial regression coefficients were also calculated using stretch at 500- and 800-ml. freeness as the dependent variable. Zero-span tensile strength fiber length, per cent summerwood, and per cent juvenile wood were the increment core variables used to predict stretch. Multiple correlations of $R = .539$ and $R = 0.485$ were obtained for the 800- and 500-ml. freeness levels. The results of these calculations indicate that stretch is not adequately predicted by the increment core variables used. Zero-span tensile strength was negatively correlated with stretch and was the variable that accounted for a major portion of the predictable variation.

Discussion

Elaborate within tree wood property comparisons have not been attempted in this study. The limited comparisons presented serve to emphasize the difficult sampling problem that exists. The correlations between increment core and whole tree wood properties are encouraging when one considers the changes that occur from the center of the tree outward along with the changes that occur in wood properties with increasing sampling height. The correlation coefficients obtained indicate that satisfactory whole tree estimates of per cent lignin, per cent summerwood, per cent extractives, per cent juvenile wood, and specific gravity can be made from b. h. increment core samples.

The analysis of variance calculations on handsheet strength properties proved useful in checking the accuracy of the strength measurements on duplicate cooks and in demonstrating that significant strength property differences existed between trees. This is very encouraging from the geneticist's point of view, particularly when it is considered that the trees sampled are from a fairly limited population and growing under uniform climatic and site conditions.

Zero-span tensile strength was the only strength property that failed to show significant differences between trees. The lack of differences between trees is due to the large mean square values associated with cooks and experimental error. The magnitude of the values indicates the sensitiveness of zerospan measurements to processing variables. The highly significant correlation coefficient ($r = 0.670$) between zero-span on the increment core pulp and the average zero span obtained for the whole tree pulp was very encouraging. Although this correlation is not as high as for several other increment core — whole tree wood properties, the results indicate that satisfactory estimates of wohle tree fiber strength (zero-span) can be obtained by the use of increment core data.

The correlations between increment core and whole tree wood property measurements and whole tree pulp handsheet data are useful in obtaining the over-all picture regarding trends and relationships that exist between wood properties and pulp strength properties. When handsheet strength properties are examined it is interesting to note that tear, for example, increases as the specific gravity and per cent summerwood in the tree increases. Burst and tensile strength, on the other hand, are negatively correlated with the percentage of summerwood and specific gravity and increase when zero-span tensile strength and fiber length increase. It is gratifiying to observe that increment core and whole tree wood property correlations with whole tree handsheet strength properties are identical in sign and have r values of similar magnitude. It should, however, be kept in mind that the relationship presented exists only within the limits of the data used in these calculations. Large wood property variation from the levels used in this study could conceivably modify the presented trends.

Basic research dealing with handsheet strength tests has established the premise that fiber dimensions, fiber strength, and fiber-to-fiber bonding are the factors that contribute most to the strength properties of a pulp. The relative importance or contribution of these three factors depends in part upon the strength property under consideration. Direct and indirect measures of fiber length and fiber strength have been obtained from increment cores taken at b. h. Multiple regression and multiple correlation calculations have been made using increment core measurements as the independent variables and pulp handsheet properties as dependent variables. The primary aim of these calculations was to determine if adequate predictions of strength properties could be made from the limited amount of data that was available from increment core samples. Fiber-to-fiber bonding is the variable which is not adequately accounted for in the multiple regression calculations that have been recorded in the Results section. When the multiple correlation values are low and a large part of the variation is not accounted for by the regression equation, as for example, in the case of tear, this has been interpreted to mean that fiber-to-fiber bonding is of greater importance than when multiple correlation coefficients are high.

Another topic that should be considered deals with the problems that might arise if a single wood property were stressed in tree improvement work to the exclusion of all others. High specific gravity, which has had an important place in tree selection work in the South because of its influence on pulp yield[7]) is an excellent example. The standard partial regression coefficients and the simple correlation coefficients indicate that wood with a high specific gravity, when such specific gravity results from a high per cent summerwood, will produce pulps having high tear and low burst and tensile strength..

The seriousness of such a procedure hinges on the importance of the tensile and bursting strength in the commercial product, the degree of genetic control over specific gravity, and the extremes to which specific gravity selection has been carried out. Fortunately, most programs have not gone overboard in the use of specific gravity and have in some cases included fiber length as an additional factor influencing tree selection. Using high zero-span tensile strength, to the exclusion of other wood property variables, as a basis for wood quality evaluation could be equally risky although apparently not as serious as high specific gravity. Zero-span tensile strength is positively correlated with tensile strength and burst, negatively correlated with stretch and apparently has very little influence on the over-all trend of the tear factor.

The best approach to wood quality evaluation seems to be the use of several wood property variables and the multiple regression technique for predicting tear, burst,

[7]) Pulp yield when calculated on a volume basis has been found to be correlated with specific gravity.

and tensile strength. The multiple regression calculations indicate that the inclusion of some measure of fiber-to-fiber bonding is worthy of further investigation.

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Summary

Twenty-four randomly selected slash pine trees growing on Union Bag-Camp Paper Corporation land near Waresboro, Georgia were sampled using 10 millimeter breast high increment cores. Micropulps were prepared and the wood evaluated for quality. Ten months later, representative wood samples of the previously evaluated trees were obtained by felling the trees, bucking them into 30-inch bolts and using every third bolt as a source of disk and chip samples. The disks, located every ninety inches along the stem, were used to obtain whole tree specific gravity, per cent summerwood, per cent juvenile wood, per cent heartwood, and per cent compression wood. Chip samples obtained from the thirty-inch bolts of each tree were composited and duplicate kraft cooks were made using a modified one cubic foot digester. Permanganate number, yield, and TAPPI Standard beater evaluations were performed on each of the duplicate cooks. Handsheet tests made included zero-span tensile strength, tensile strength, stretch, energy to rupture, tear factor, bursting strength, formation, caliper, and apparent density. Chemical analyses include alcohol-benzene extractives and per cent lignin.

A highly significant correlation was obtained between zero-span tensile strength measurements made on increment cores and zero-span tensile strength measurements made on pulp samples representative of the entire tree. Fiber length measurements made on 10 millimeter breast high increment cores were found to be significantly correlated (2% probability level) with whole tree fiber length measured on the pulp. Comparisons made, indicate that satisfactory whole tree estimates could be obtained for per cent lignin, per cent summerwood, per cent extractives, per cent juvenile wood, and specific gravity by using 10 millimeter breast high increment core data. Analysis of variance data indicated that significant differences existed between trees in the paper strength properties of tear, burst, tensile strength, and stretch. This is particularly encouraging considering the circumstances of sampling and indicates possible areas for genetic improvement.

Multiple regression and multiple correlation analyses were run using increment core data to predict handsheet strength properties. These calculations indicate that increment core data could be used to obtain satisfactory estimates of bursting strength and tensile strength. Tear factor estimates were not as satisfactory as desired and must be improved before they will be useful in more exacting genetic studies. Zero-span tensile strength measured on increment cores was the single variable that contributed most to the prediction of bursting strength and tensile strength. Zero-span tensile strength and per cent juvenile wood contributed about equally to the prediction of tear factor.

Zusammenfassung

Titel der Arbeit: *Messung der Holz- und Zellstoffeigenschaften von Pinus elliottii an Bohrspänen und ganzen Stämmen.*

Von 24 zufällig ausgewählten Bäumen von *Pinus elliottii* aus Beständen der Union Bag Paper Corporation bei Waresboro, Georgia, wurden in Brusthöhe 10 mm starke Bohrspäne entnommen. Fasersuspensionen wurden hergestellt und die Qualität des Holzes bewertet. 10 Monate später wurden die Bäume gefällt und in 30 Zoll lange Abschnitte aufgeteilt. Jeder dritte Abschnitt lieferte Stichproben in Form von Stammscheiben und Bohrspänen. Die Stammscheiben aus Abständen von jeweils 90 Zoll dienten der Bestimmung des spezifischen Gewichts, des Anteils von Jugendholz, Spätholz, Kernholz und Druckholz. Bohrspäne von den 30 Zoll langen Abschnitten eines jeden Baums wurden gemeinsam in einem modifizierten Ein-Kubikfuß-Aufbereiter doppelten Sulfatkochungen unterworfen. An jeder dieser Doppelkochungen wurden Permanganatzahl, Ausbeute und Mahlgrad nach TAPPI-Standardprüfverfahren (TAPPI Standard beater evaluation) bestimmt. Die Prüfung von Papierprobeblättern umfaßte die Zugfestigkeit von Einzelfasern bei Einspannlänge Null, Zugfestigkeit, Spannung, Brucharbeit, Durchreißfaktor, Berstfestigkeit, Entwicklung (formation), Faserdurchmesser (caliper), und scheinbare Dichte. Chemische Analysen bestanden in der Ermittlung der in Alkohol-Benzol extrahierbaren Stoffe und des Ligninanteils.

Es wurde eine hochsignifikante Korrelation gefunden zwischen Messungen der Zugfestigkeit von Einzelfasern bei Einspannlänge Null an Bohrspänen einerseits und an Zellstoffproben, die den ganzen Stamm repräsentierten, andererseits. Messungen der Faserlänge an 10 mm starken Bohrspänen aus Brusthöhe waren bei $P = 0{,}02$ korreliert mit Faserlängenmessungen über den ganzen Stamm am Zellstoff. Angestellte Vergleiche zeigen, daß für den ganzen Stamm hinreichende Schätzwerte für den Anteil von Lignin, Spätholz, extrahierbaren Stoffen, Jugendholz und für das spezifische Gewicht aus 10-mm-Bohrspänen aus Brusthöhe gewonnen werden können. Die Varianzanalyse ergab signifikante Unterschiede zwischen Bäumen inbezug auf Durchreißfaktor, Berst- und Zugfestigkeit und Spannung. Diese Tatsache ist im Hinblick auf die Bedingungen der Stichprobenahme besonders ermutigend und eröffnet Möglichkeiten für die Züchtung.

Multiple Regressions- und multiple Korrelationsanalysen sollten zeigen, ob aus Bohrspanmessungen die Festigkeitseigenschaften von Papierprobeblättern vorhergesagt werden können. Diese Berechnungen ergaben, daß Bohrspandaten zufriedenstellende Schätzwerte für Berst- und Zugfestigkeit abgeben. Schätzwerte für den Durchreißfaktor zeigten nicht die erwünschte Zuverlässigkeit und bedürfen vor Anwendung in eingehenderen genetischen Untersuchungen der Verbesserung. Die Zugfestigkeit von Einzelfasern bei Einspannlänge Null war das Merkmal, das am ehesten die Vorhersage der Berst- und Zugfestigkeit aufgrund von Messungen an Bohrspänen erlaubte. Die Zugfestigkeit von Einzelfasern bei Einspannlänge Null und der Jugendholzanteil leisteten etwa den gleichen Beitrag zur Vorhersage des Durchreißfaktors.

Résumé

Titre de l'article: *Propriétés du bois et de la pâte de slash pine déterminées à partir de carottes prises à la tarière de Pressler, comparées aux mesures sur l'arbre entier.*

Des carottes de 10 mm de diamètre ont été prélevées sur 24 *slash pines (Pinus elliottii)* pris au hasard sur un terrain de l'*Union Bag Camp Paper Corporation,* près de Waresboro, Georgie. Des échantillons de pâte ont été faits à partir de ces carottes et la qualité du bois a été évaluée. Dix mois plus tard, ces mêmes arbres ont été abattus et des échantillons de bois représentatifs ont été obtenus en les découpant en billons de 30 *inches* et en prenant un billon sur trois pour constituer les échantillons de rondelles et de copeaux. Les rondelles, réparties tous les 90 *inches* le long de la tige, ont servi à mesurer la densité globale, les pourcentages de bois d'été, de bois juvénile, de bois de coeur, et de bois de compression. Les échantillons de copeaux de tous les billons de 30 *inches* de chaque arbre ont été réunis et pour chaque lot on a fait deux cuissons kraft dans un cuiseur de un *cubic foot* modifié. On a mesuré sur chaque cuisson l'indice au permanganate, le rendement et l'essai »TAPPI standard«. Sur des feuilles faites à la main on a fait les essais de résistance à la tension, allongement, résistance à la rupture, facteur de déchirure, résistance à l'éclatement, formation, calibre et densité apparente. Les analyses chimiques ont porté sur les extraits à l'alcool-benzène et la teneur en lignine.

On a mis en évidence une corrélation hautement significative entre la résistance à la tension *(»zero-span«)* mesurée sur les carottes et la même valeur mesurée sur les échantillons représentatifs de l'arbre entier. La longueur des fibres mesurée sur les carottes et la longueur des fibres de tout l'arbre mesurée dans la pâte sont en corrélation significative (au seuil de 2%). Les autres comparaisons indiquent que des estimations satisfaisantes peuvent être obtenues des mesures sur des carottes de 10 mm de diamètre pour la teneur en lignine et en extraits, la proportion de bois d'été et de bois juvénile, et la densité. L'analyse de variance montre que des différences significatives existent entre les arbres pour les propriétés de résistance du papier, déchirure, éclatement, résistance à la tension et étirement. Cela est tout à fait encourageant si l'on se réfère à l'échantillonnage et ouvre un champ d'action possible pour l'amélioration génétique.

Des analyses de régression multiple et de corrélation multiple sur les données obtenues sur les carottes ont été effectuées pour prédire les propriétés de résistance du papier. Ces calculs indiquent que les mesures sur carotte pourraient être utilisées pour obtenir des estimations satisfaisantes de la résistance à l'éclatement et à la tension. Les estimations du facteur de déchirure n'ont pas été aussi satisfaisantes et doivent être améliorées avant de pouvoir être employées dans des recherches plus précises de génétique. La résistance à la tension *(»zero-span«)* est la variable mesurée sur carottes qui contribue le plus à la prédiction de la résistance à l'éclatement et de la résistance à la tension. Cette variable et la proportion de bois juvénile contribuent à peu près également à la prédiction du facteur de déchirure.

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