A

RELATIVE RATES OF DECAY OF LOPPED AND UNLOPPED DOUGLAS FIR SLASH

A THESIS

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INTRODUCTION

This study was instituted in April, 1936, when Prof. T. J. Starker raised the question of whether lopped or unlopped logging slash of Douglas fir, Pseudotsuga taxifolia (Poir) Britt., would decay faster in our Western Oregon climate.

In direct connection arose the question, "When is wood rotten?" In other words, for a careful study of the situation, a quantitative measure of disintegration had to be decided upon.

PREVIOUS WORK ON THE SUBJECT

Long (2) made a study of slash decay in Arkansas and found that slash, lopped and scattered, decayed more rapidly than when piled or pulled. He found practically no difference between lopped and unlopped slash on dry areas such as southern and western slopes of steep hillsides. In this case moisture was considered a limiting factor of decay, and the slash close to the ground received more dew. In this study, no method of measuring decay is indicated. It apparently was based on the judgement of the author.

Spaulding (4), in a study of slash decay of white pine in New England, bases the extent of decay on visual inspection for deterioration. He does not consider the relation of lopped to unlopped slash.

There has been some work done on a quantitative measure of decay of wood. None have worked on empirical samples, but on originally sound samples in controlled tests. Regular sized and shaped blocks inoculated with cultures of various fungi, were used.

Steinmetz & Hillborn (5) experimented with the heat of combustion of red maple cordwood and found a consistent decrease in BTU's per cord per year of exposure. By testing 1 gram samples they estimated that a cord of wood contained 70, 60, 59, and 38 million BTU's, respectively, for each autumn after cutting for the four years of their tests.

Weirtelak (6) studied Douglas fir infected with *Trametes pini* (Brot) Fr. and found an increase in cellulose content and a decrease in lignin content in comparison with uninfected parts of the same board. He made more tests on loblolly pine sapwood and found a 15.3% maximum loss in weight for the first stages of decay.

Schmitz and Daniels (3) and Zeller (7) made tests on woods of various species and used per cent loss in weight as the measure of decay. The two studies embraced a considerable number of woods and species of fungi in controlled tests on wood blocks, inoculated with fungi from pure cultures.

PURPOSE OF THE STUDY

The purpose of this study is three fold, though lack of time and facilities for gathering data will limit it.

1. To determine whether lopping Douglas fir slash hastens its rate of decomposition. This is rather a pertinent question for Pacific Northwest foresters who oppose the principle of broadcast burning and yet are interested in the period of intensive fire protection for cutover areas- and in any measures that may shorten this period. Lopping of slash costs money, and in case it has no benefits it is a useless expenditure.

2. To find the length of time necessary for complete deterioration of the material and to arrange this in a table so that, for any given area, the present degree of decay could be measured, and from this the period left for intensive protection could be calculated. Due to lack of time and facilities for gathering data, this phase of the study has been abandoned so far as this thesis is concerned.

3. To find a method of quantitatively measuring the extent of decay. It is desirable that this method be comparatively simple and that it shall not require specialized and expensive equipment unobtainable by the forester in the field.

EQUIPMENT AND MATERIALS USED

Equipment used was an electric oven with thermostatic temperature control and a set of scales reading to the nearest one gram on a dial. Any type of accurate scales could be used but these were preferred because they speeded up the weighing of a large number of samples. Standard laboratory glass cylinders graduated in cubic centimeters (CC's) were used.

The samples, themselves, were sections of branches about six inches long. For the sake of uniformity, bark was removed from all samples. These samples were taken on the McDonald forest from trees on the west side of the road, opposite the new improvement cutting on top of the hill. These trees have been down since 1931 and a dense growth of fern, grass, and weeds covers the ground. The aspect is west at the crest of the ridge. In all cases the samples are paired, one taken from an unlopped branch and one from a lopped or broken off branch lying on the ground, but originating from the same part of the crown of the same tree.

In the experiments on technique, materials used were:

1. Vetch seeds for dry displacement tests.
2. Silica sand for dry displacement tests.
3. Water for liquid displacement tests.
4. Paraffin used as a waterproofing material for part of the liquid displacement tests.

METHODS USED

There is a choice of at least three methods of measuring decay.

1. Chemical analysis.
2. Heat of combustion.
3. Decrease in specific gravity.

The first two were eliminated because they would require a skilled technician and specialized laboratory equipment to carry them out. This left specific gravity as the only practicable method that would attain the results desired.

Specific gravity is easily obtained by dividing oven dry weight by volume. However, a fast accurate method of obtaining volume of an irregular shaped object was not so easy. There are two possible and easily workable methods.

1. Displacement in a dry medium.
2. Displacement in a liquid medium.

The advantage of dry displacement is that the samples do not need any treatment and volumes can be taken on samples and these same samples later analyzed by one of the other methods. The same samples may be exposed to further decay if it is desired.

Dry vetch seed was tried first. A cylinder was filled with seed and shaken a uniform number of times, and then the excess above the top of the cylinder was leveled off with a straight edge to insure uniform filling of the cylinder for each test. The filled cylinder was weighed and weight of filled cylinder less weight of empty vessel equaled weight of seed for this cubic volume. As this medium was too variable it was discarded.

A supply of silica sand which has nearly spherical particles of fairly uniform size was obtained from the soils department and used as the next dry displacement medium. This was shaken down in a standard method by being dropped from a given height onto a magazine a definite number of times. This gave uniform density of sand for each test. The container filled with sand was weighed for a number of times to get the average density of the sand. Then the jar was filled with sand and one sample and weighed. From the weight of the sand displaced, the volume of the sample was calculated. This method was fairly accurate, but very slow, and was discarded for this reason.

Actual displacement of untreated stick in water was next tried. The stick was submerged in a graduated cylinder, partly filled with water, and the volume displacement read directly in CC's. This method was fairly rapid and simple. The main objection was that, as the diameter of the stick increased, a larger graduate was necessary and the accuracy of reading fell off due to the larger number of CC's per graduation on the cylinder. This method was checked against regular sticks of known calculated volumes obtained by measurements and as the amount of surface increased, the error also increased.

From all the above tests it was decided to treat the sticks by immersion in hot paraffin and then obtain volume by weight of water displaced when sample was submerged. The samples were waterproofed and held under water in a large jar by means of a dissecting needle. The jar of water was balanced at zero reading on the large scales used in these tests and the volume read directly as the increase in weight when the sample was completely submerged. This method is simple, fast, and accurate and, for the purpose of this study, quite suitable as the samples are discarded after the specific gravity is determined.

Dry displacement in metal shot, and liquid displacement in mercury were not attempted due to the expense of the shot and mercury.

RESULTS

TESTING OF METHODS:

The samples gathered in April, 1936 had volume determinations made by two methods: (1) dry displacement in silica sand, and (2) wet displacement of water in a graduated cylinder, using untreated sticks for each test. Volumes and resultant specific gravities for the sample are compared in Table I. Using water displacement, method 2, as a standard; volume by dry displacement in sand, method 1, is 3.57% low, and specific gravities are 4.2% high. Unfortunately the samples were destroyed at this point before volume was determined by the last and adopted standard method, namely, weight of water displaced by the paraffin coated sample, method 3.

A few regularly shaped cylinders and blocks of wood were secured, their approximate volume in cubic centimeters was computed, and then they were tested by the three immersion methods: (2) Submerging untreated block in a graduated cylinder partly filled with water and reading the displacement. (3) Submerging paraffin coated block in a vessel of water balanced on a scale, the increased weight equals the weight of the water displaced which equals the volume of the object in cubic centimeters. (4) Submerging paraffin coated block in a graduated cylinder of water as in method 2.

Method 2 ran consistently high and the error increased as the surface exposed increased. Methods 3 and 4 gave the same result if 4 was very carefully done, otherwise method 4 is apt to give high reading due to water drops adhering to the surface of the sample. Another objection to method 4 is that, for the smaller sticks, a 250 CC graduate was used. This is graduated to the nearest two CC's, but in the next larger size, the smallest graduation is five CC's which decreases the accuracy of the readings. A further objection to the method is that there is a chance of making a mistake in the mental arithmetic performed with each immersion to get the volume of the sample.

Method 3 can be done rapidly, any degree of desired accuracy can be attained by using a scales of the desired delicacy, and the volumes can be read directly by counterbalancing the vessel of water at zero weight.

Method 2 and 3 are compared in table II, using samples obtained in November, 1936, as the basis. Using method (3) as the standard, method (2) was found to be 4.53% high for volume and 9.11% low for specific gravity.

The values for all three methods are summarized in table III. Also the correction factors to use in converting values from the other methods to method 3.

Since Method No. 3 is faster, easier, and more accurate than the other methods, it was used to the exclusion of the others, and all values given in this thesis are by this method, either directly or by conversion, unless specifically stated otherwise.

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TABLE I.

A comparison of volume and specific gravity of Douglas fir limbs as obtained by two different methods of volume determination for the same piece. Method 1, displacement in dry silica sand, using weight of sand displaced. Method 2, displacement of water in a graduated cylinder, stick untreated. Volumes are in cubic centimeters.

VOLUMES		SPECIFIC GRAVITY	
Sand	Water	Sand	Water
107	110	.542	.527
110	111	.536	.536
75	76	.533	.527
107	110	.542	.527
91	94	.517	.500
57	63	.572	.509
70	72	.528	.515
60	62	.467	.452
96	95	.606	.611
92	91	.577	.583
88	89	.580	.574
75	76	.560	.553
62	65	.549	.523
76	79	.645	.620
86	86	.558	.558
77	77	.585	.584
72	72	.583	.583
61	62	.558	.549
48	48	.542	.542
65	69	.678	.638
59	67	.678	.597
57	62	.632	.581
51	58	.647	.579
37	46	.676	.544
34	40	.618	.525
1813	1880	14.419	13.837

sand 3.57% low

sand 4.2% high, using water, method 2, as basis.

TABLE II

A comparison of volume and specific gravity of Douglas fir limbs as obtained by two methods of volume determination for the same piece. Method 2, by displacement of water in a graduated cylinder by the untreated stick. Method 3, by weight of water displaced by the paraffin coated stick.

	VOLUME		SPECIFIC GRAVITY	
Method	#2	#3	#2	#3
	104	101	.490	.505
	51	49	.471	.490
	130	126	.562	.579
	76	73	.514	.534
	32	31	.500	.516
	83	80	.470	.487
	89	86	.506	.523
	90	86	.566	.594
	64	61	.547	.574
	52	51	.731	.745
	34	33	.559	.576
	78	75	.615	.640
	50	49	.540	.551
	100	95	.600	.632
	72	68	.514	.544
	121	116	.579	.603
	98	93	.552	.581
	81	73	.518	.575
	102	97	.500	.527
	91	87	.538	.564
	90	86	.544	.570
	63	61	.461	.476
	70	67	.572	.597
	63	61	.587	.607
	63	60	.587	.618
	66	62	.606	.646
	64	61	.609	.640
	57	54	.509	.537
	90	85	.523	.553
	98	94	.500	.521
	107	103	.542	.563
	114	107	.623	.657
	103	99	.534	.556
	133	128	.587	.607
	91	88	.538	.557
	61	58	.624	.655
Sum	2931	2804	19.818	20.702

Using weight of water displaced as the standard, displacement in a graduate is 4.53% high in volume, and 9.11% low for specific gravity.

TABLE III

A comparison of values for volume and specific gravity when volume is determined by the following three methods.

1. Displacement in dry sand.
2. Displacement of water by untreated stick in graduated cylinder.
3. Weight of water displaced by paraffined stick.

	Meth. 3	Meth.2	Meth. 1
Volume	100.0 %	104.5 %	101.1 %
Specific Gravity	100.0 %	95.7%	99.6 %

Correction factor for converting to method 3 values.

Specific Gravity	0	1.044	1.001
Volume	0	.957	.989

RESULTS

RELATIVE DECAY RATES OF LOPPED AND UNLOPPED SLASH

Specific gravity being used as an index of extent of decay, there are a number of ways to compare the data.

An attempt was made at the time of collection to get paired samples, one lopped and one unlopped from the same part of the tree crown.

In the sampling done in April, entire limbs were paired, while in the November sampling each sample was paired with another from the same part of the tree crown and, in addition, they were matched for approximate diameter and distance from bole. This data is presented in Table IV. It cannot be analysed but does show a definite trend.

Some people have advanced the theory that limbs attached to the bole draw on the main trunk as a water reservoir thus facilitating decay. This hypothesis was borne in mind when the second set of samples was taken and distance in feet from the bole to the point where the sample was cut out of the limb was recorded for each sample. These samples were divided into diameter classes and a curve drawn for each diameter class. Lopped and unlopped samples were kept separate and a curve for each within the diameter class was drawn, plotting specific gravity over distance from bole. All curves follow the same general shape except one, which may be due to an insufficient basis. These curves are shown in Figure No. 1.

Inasmuch as a limb decays from the outside toward the center, a large limb decayed to the same depth as a small one will still have

TABLE IV

A comparison of specific gravity of lopped and unlopped slash collected on the McDonald forest in 1936 from thirteen Douglas fir trees that had been down since 1931. Basis, 100 samples, paired, lopped and unlopped from the same part of the crown of the same tree.

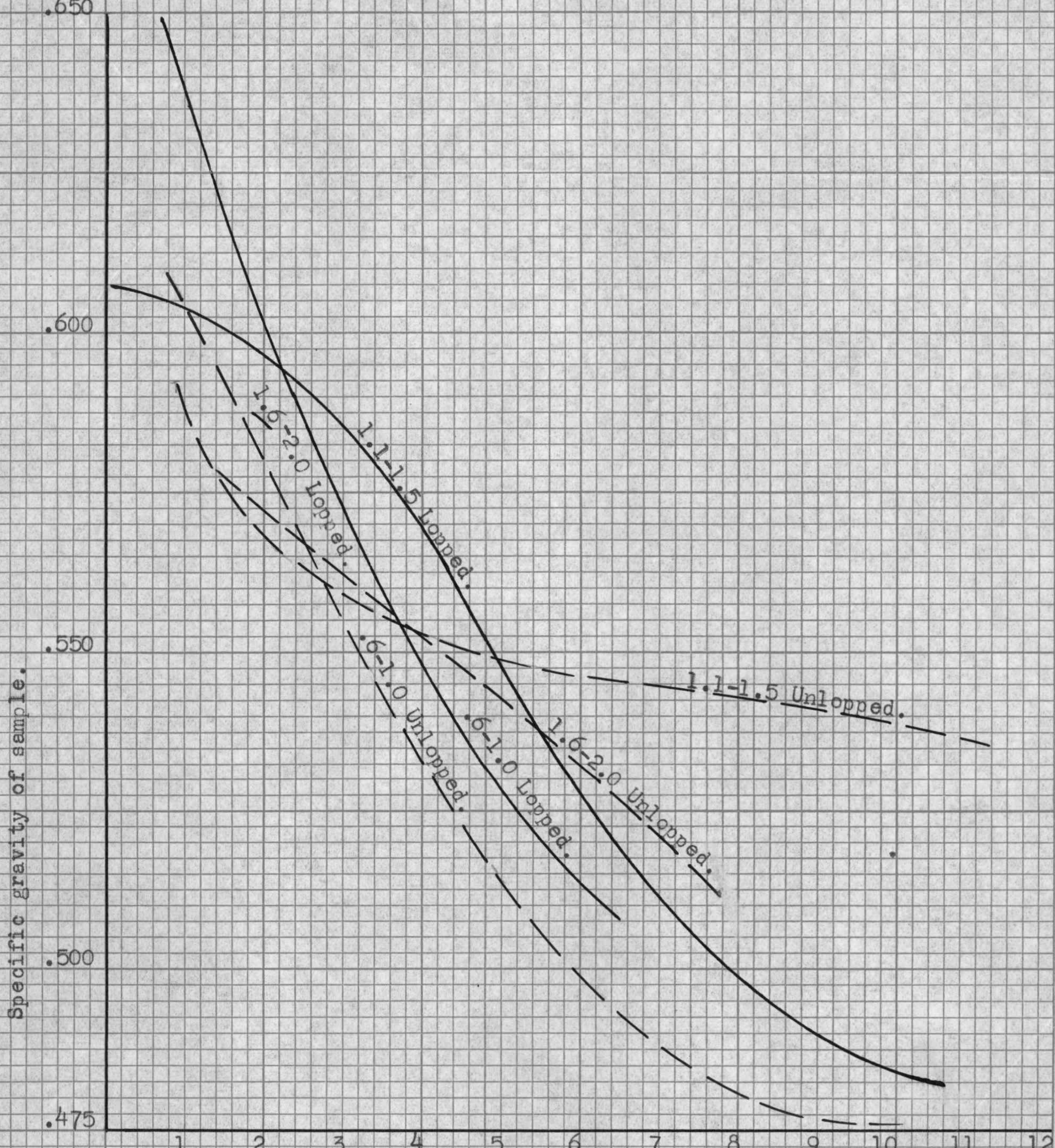
Comparisons are of averages from each tree as a unit.

	Unlopped	Lopped	
April collection			
	.534	.594	
	.598	.603	
	.531	.582	
	.642	.625	
	.603	.616	
	.583	.607	Average for group.
November collection			
	.533	.534	
	.584	.660	
	.592	.560	
	.575	.585	
	.551	.599	
	.475	.559	
	.607	.608	
	.556	.546	
	.558	.585	Average for group

Figure 1.

Average specific gravity of lopped and unlopped Douglas fir slash collected on McDonald forest November 1936, from trees down since 1931. Relationship of specific gravity to distance from bole to point of sample, curves by size classes of diameters in inches.

Basis 50 samples.



a larger percentage of sound heart wood. Obviously, when comparing specific gravities of the two, the large limb will have a much higher specific gravity than the other due to this core of sound wood. So, assuming that both have the same original specific gravity, it is poor statistics to compare one against the other. Without knowing the average depth of decay for each it would be practically impossible to work out a correction factor, so by far the easiest and best solution is to compare specific gravities of limbs of the same diameter.

No diameters were recorded for the samples collected in April but all samples were cut about the same length so that a definite relationship exists between volume and diameter. This is not absolutely accurate for any one sample as lengths were estimated and not measured precisely, although the first samples were measured more closely than the second group. From the data on the second group of samples a curve of volume over diameter was drawn, Figure 2, and from this curve average volumes for a given diameter were obtained, Table V. Although not absolutely accurate, it is close enough for the purpose desired, namely to plot average curves of specific gravity over diameter, and average curves were drawn for both lopped and unlopped slash, Figures 3 and 4.

There was one complete growing season between the two collections of samples so the curves from figures 3 and 4 were combined in figure 5 to compare increased deterioration with the passage of time if this decay was measurable for this length of period. However the basis is too weak to draw other than the broadest of conclusions,

Figure 2

Average volume for a given diameter of slash sample collected in November, 1936 on McDonald Forest. Douglas fir limbs, both lopped and unlopped. Basis 50 samples.

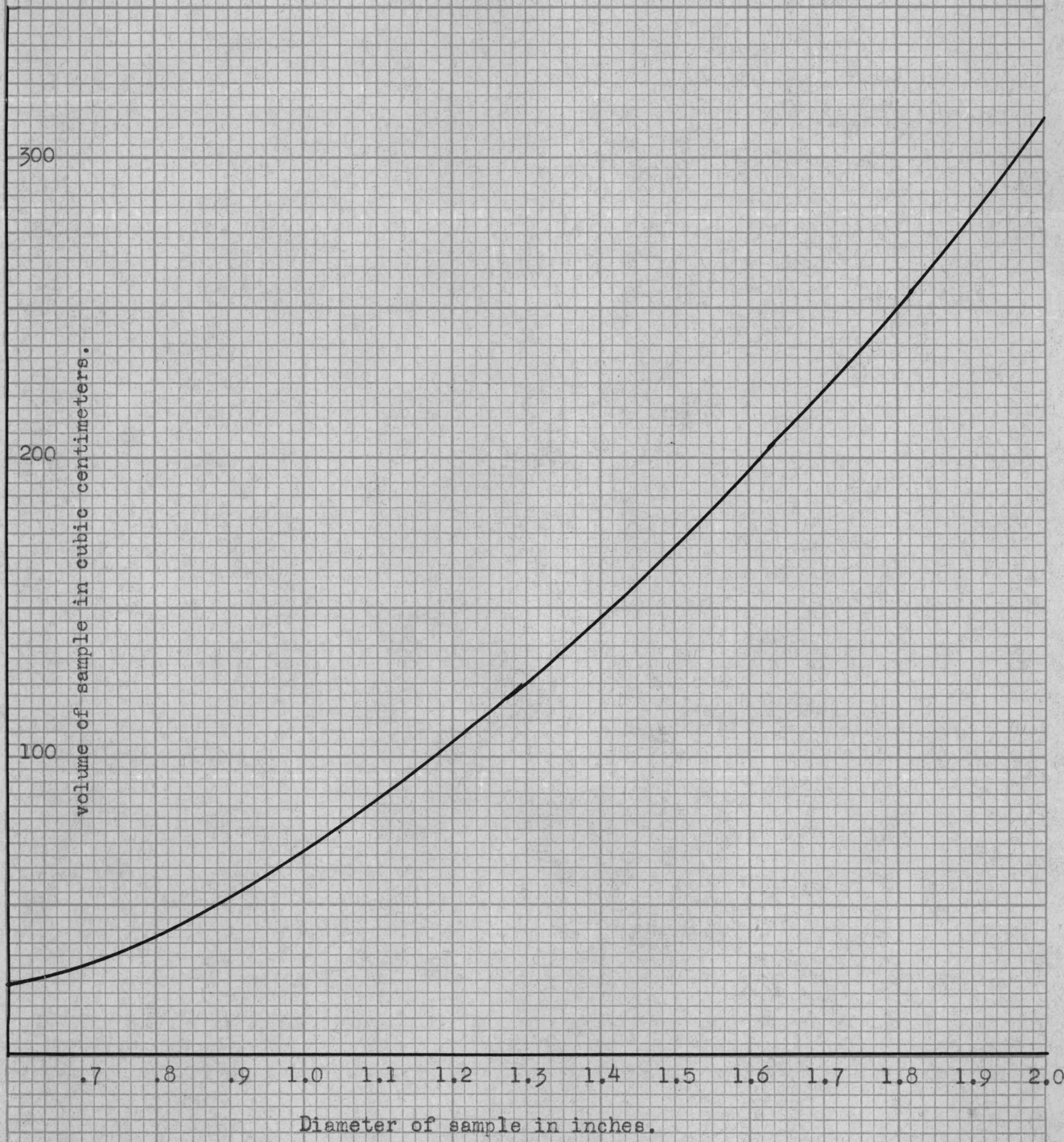


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TABLE V

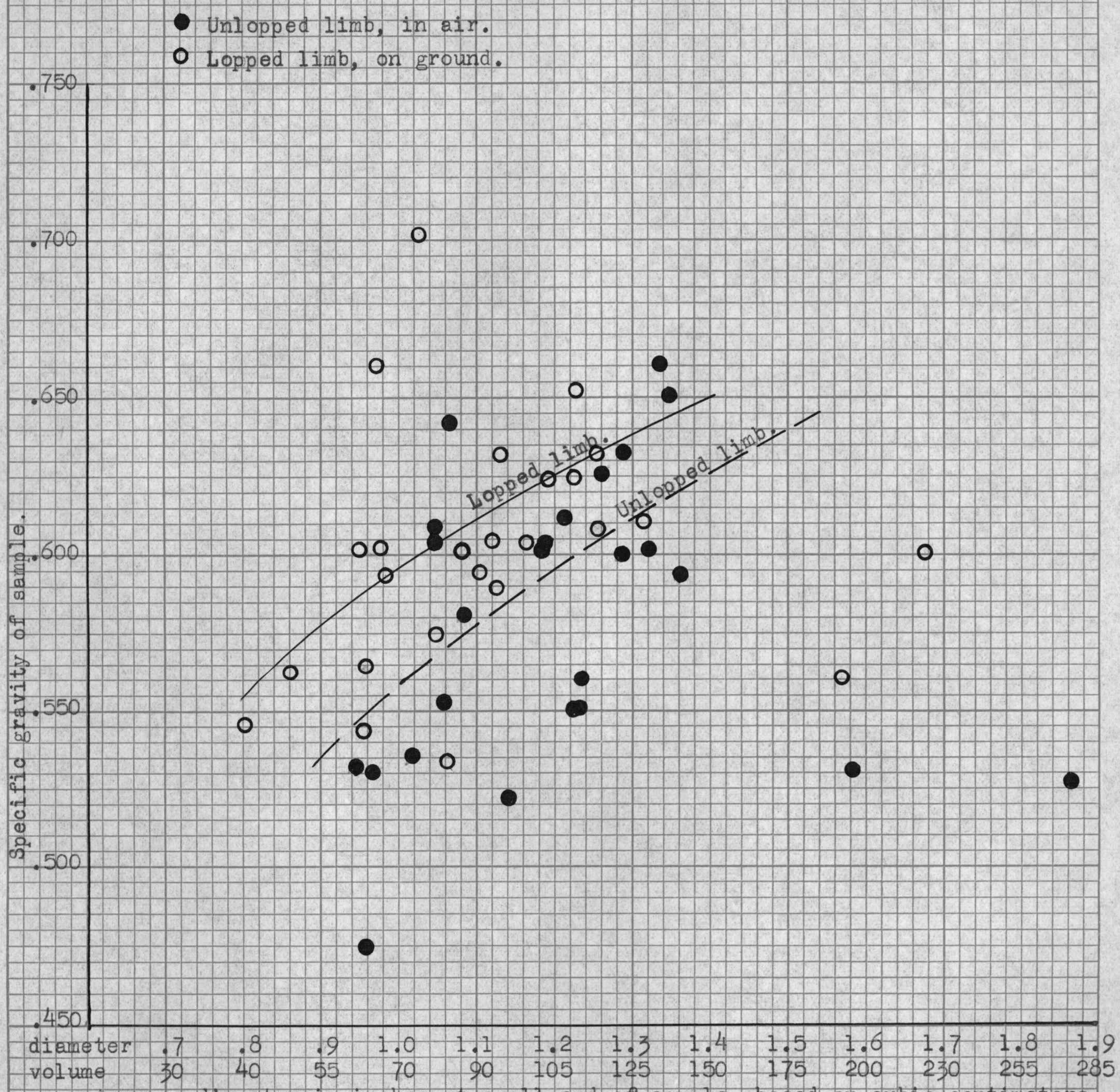
Average volume for a given diameter of Douglas fir slash sample collected in November 1936, on McDonald forest. Values from curve in Figure 2.

Diameter inches	Volume cu. centimeters
.7	30
.8	40
.9	55
1.0	70
1.1	90
1.2	105
1.3	125
1.4	150
1.5	175
1.6	200
1.7	230
1.8	255
1.9	285
2.0	320

basis 50 samples

Figure 3

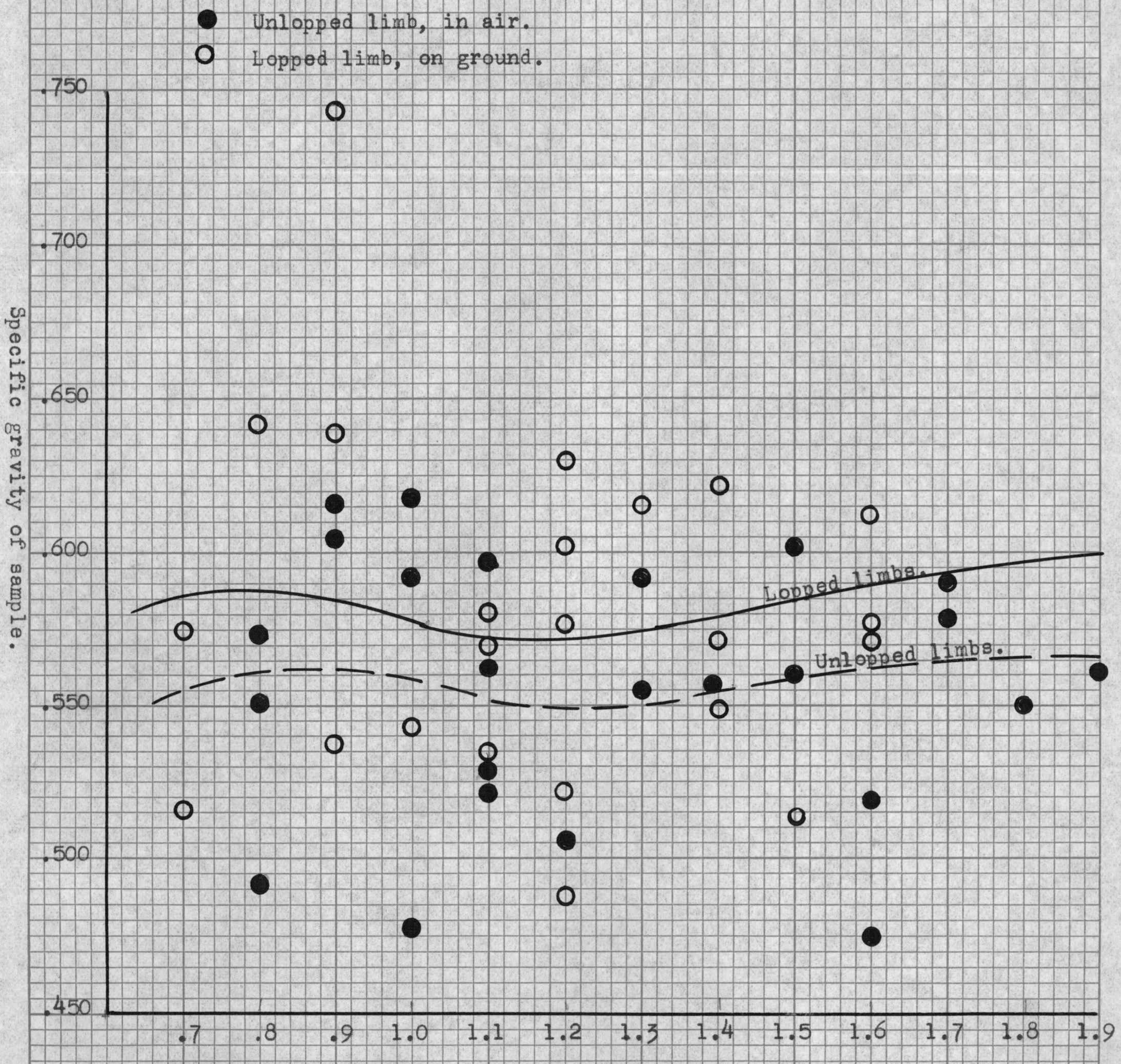
Average specific gravity of samples of lopped and unlopped Douglas fir slash collected April, 1936, on McDonald forest from trees down since 1931. Relationship of specific gravity to diameter of sample in inches. Basis 50 samples.



Average diameter in inches at small end of sample, based on cubic centimeters of volume for each sample.

Figure 4

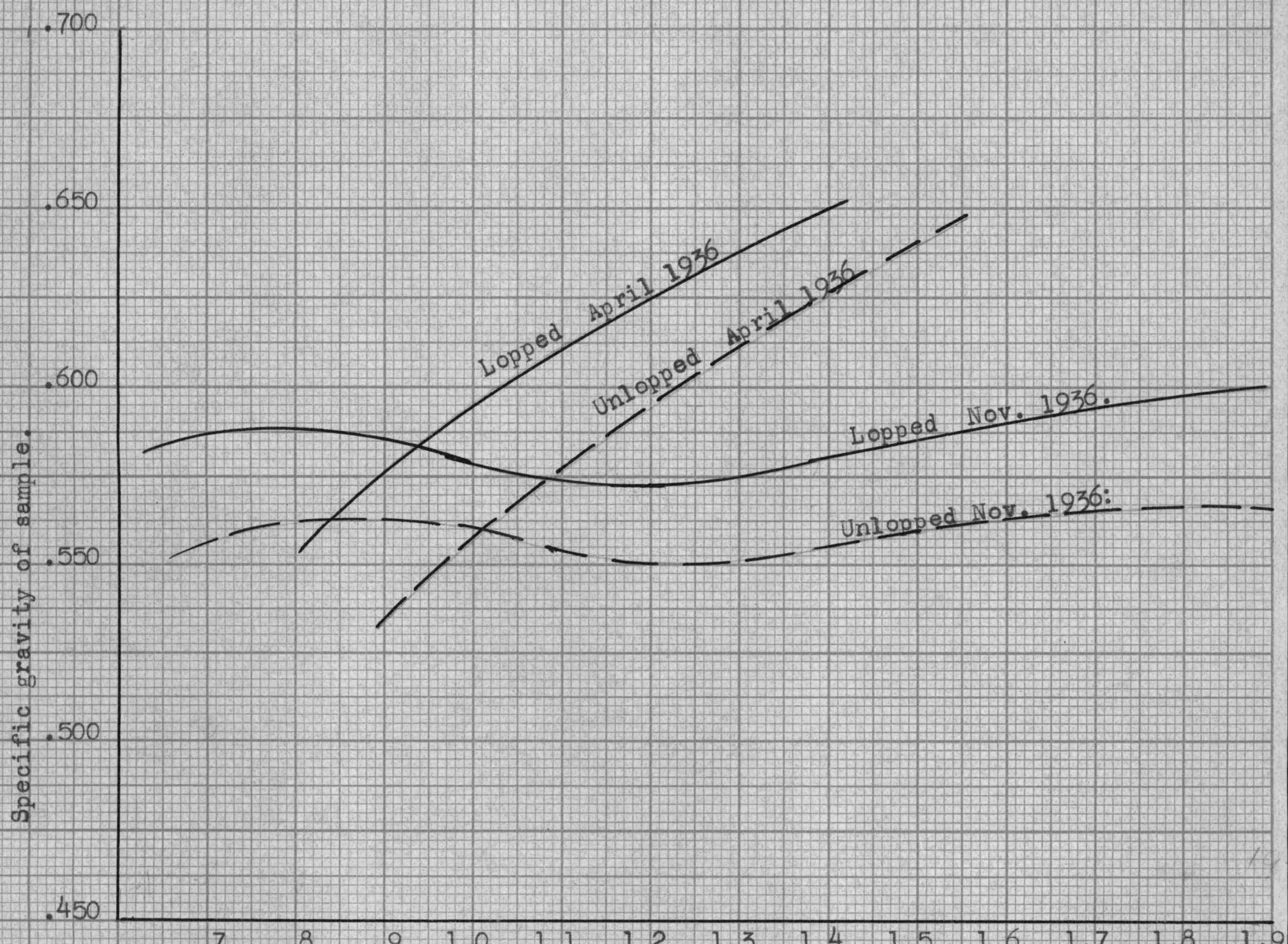
Average specific gravity of samples of lopped and unlopped Douglas fir slash collected November 1936, on McDonald forest from trees down since 1931. Relationship of specific gravity to diameter of sample in inches. Basis 50 samples.



Average diameter in inches at small end of sample.

FIGURE 5.

A comparison of the average specific gravities of lopped and unlopped slash of Douglas fir from trees down since 1931. Data taken in April, 1936, and again in November, 1936, from the same area on the McDonald forest. Showing possible progress of decay for this eight months period. Basis 100 samples. Curves from Figures No. 3 and No. 4.



namely that, as time passes, decay progresses.

In Table VI the average specific gravities by diameter classes is shown. In addition, the average for two live limbs collected in April is shown, diameter .9 to 1.0 inches. A few samples of lopped slash, fresh in April were collected in November. There was no evidence of decay although insects had destroyed the inner bark. The mean for these six samples, diameters .9 to 1.2 inches, is also shown on the table.

TABLE VI

Summary of specific gravity averages by diameter classes for samples collected in 1936 on McDonald forest.

Basis 100 samples, 50 each collection. 9 sound limb samples from two limbs. 6 samples one season old.

		April collection		November collection	
Diameter class		Lopped	Unlopped	Lopped	Unlopped
Inches		Specific gravity		Specific gravity	
.6	1.0	.602	.567	.601	.569
1.1	1.5	.611	.599	.569	.561
1.6	2.0	.582	.531	.588	.546

Sound limbs	.593	
One season lopped slash		.598

CONCLUSIONS

METHODS:

From the standpoint of simplicity and equipment needed, decrease in specific gravity appears to be the best quantitative measure of decay in coniferous slash.

If the samples are to be discarded after the determination is made, volume is easily and accurately determined by waterproofing the sample with paraffin or some other similar substance and submerging it in a vessel of water balanced on scales. The increased weight in grams is equal to the volume of the piece in cubic centimeters. The only equipment needed is a set of scales and a vessel of water.

In case waterproofing the samples is undesirable, dry displacement in silica sand or some other substance of a similar nature, namely, regular spherical shape and uniform size particles can be used. It is fairly accurate but slow and tedious and requires a supply of the displacement medium in addition to the scales needed above.

Wet displacement of the untreated sample in mercury can also be used. Some investigators have used this method for precise work.

RESULTS:

1. Relation of distance from bole to rate of decay.

On examining the curves in Figure 1, it can be seen that there is a consistent decrease of specific gravity as distance from the bole is increased. On examining the curves in Figures

3 and 4 we find an increase in specific gravity with an increase in diameter. This alone would cause the characteristic shape of the curves in Figure 1, and the possibility of denser wood near the bole would further accentuate it. Lopped slash is attached and unlopped slash is detached from the bole but both have the same shape curve in general which would indicate that the bole acting as a water reservoir to speed up decay was a negligible factor.

In brief, we may say that distance from bole has little or no significance. However the basis is far too weak to state whether attachment to the bole is of significance or not, other than as a means of support. Lopped slash shows a consistently ? lower ~~higher~~ decay rate than unlopped slash. Some of the curves are erratic due to an insufficient basis at the ends of the curve.

2. Relation of diameter of branch to rate of decay.

Both lopped and unlopped slash show the same characteristic curve as shown in Figures 3 and 4. This is only logical that, as diameter increases, specific gravity also increases, due to the larger core of sound wood and to the higher percentage of heartwood.

In Figure 4, however, there is a rise again in branches less than one inch in diameter. The only reasonable hypothesis for this is that these smaller limbs soon lose their bark and, as a result, are dried out and casehardened to such and extent as to discourage decay, while the larger limbs have more moisture and hence more nearly approximate optimum conditions for decay. Further research will be necessary to prove or disprove this point.

3. Speed of decay.

Figure 5 shows the curves for slash taken from the same area for two periods eight months apart. This data is also summarized in Table VI. There is not enough change, nor enough data to even attempt a quantitative analysis of this phase.

4. Relationship of lopped to unlopped slash and decay rates.

In all the various methods of analysis of the data, one fact is outstanding. That is that the unlopped slash has a consistently lower specific gravity, hence faster rate of decay. Unlopped slash has, roughly, a 3% lower specific gravity than lopped slash. Some trees and some limbs have a reverse relationship but this is not general and can be explained by the laws of chance that certain portions of any limb are more decayed than other spots due to an earlier inception of fungus growth. In explaining this condition it must be borne in mind that this area is on a northwest hillside, and the limbs on the ground are smothered in a dense growth of grass and weeds. One hypothesis for this condition is that the lopped slash has too high a moisture content for the greater part of the year due to abundant rain and the heavy ground cover. This is borne out by T. J. Starker's study of moisture contents of slash on this area for a period of years. In addition to too much moisture, the lopped slash may be too cold. There is no existent data on this phase however.

On the other hand, the unlopped slash is up in the air where it will be wet enough and warm enough for fungus growth to take place most of the winter in this climate in normal years.

The probability is that both locations are too dry for decay during the middle of the summer.

Whatever the reason, the fact remains that lopped slash decays measurably slower than unlopped slash from the same trees from the same area.

RECOMMENDATIONS

The only general recommendation that can be made at this time is that, unless proven otherwise for the particular area, lopping of slash is not advisable as a means of hastening decomposition.

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