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A VOLUME TABLE FOR RED MAPLE ON THE HARVARD FOREST

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Red Maple (*Acer rubrum*) is the most important of the trees cut for cordwood on the Harvard Forest. More than half of the total cut of fuel wood, and more than seventy-five per cent of the " hardwood " is of this species. Of the trees used primarily for fuel, only gray birch (*Betula populifolia*) approaches it in numbers in the Forest, and the small size of the birch makes insignificant its proportion of the total volume cut.

The maple is present on nearly every wooded acre within the Forest. The heaviest stands are in the hollows or swales where the ground is moist, but not swampy. On such situations small stands of nearly pure red maple may be found, with only a scattering mixture of other species such as white elm (*Ulmus americana*), chestnut (*Castanea dentata*), black cherry (*Prunus serotina*), white ash (*Fraximus americana*), and yellow birch (*Betula lutea*). Here the tree reaches its best development for cordwood, the usually dense stand forcing height growth to an extent that produces trees eighty to ninety feet tall, and with few large limbs. Stands of forty to fifty cords per acre are not uncommon.

In the swamps, maple occurs in mixture with red spruce (*Picea rubens*), hemlock (*Tsuga canadensis*), tamarack (*Larix laricina*), and tupelo (*Nyssa sylvatica*). On such situations the maple has a relatively poor form, caused by the poor soil and the bad treatment of the forest in the past. The trees are short, often unsound, and usually very limby or forked. As a rule the stand of cordwood is not heavy. The same poor form is found in some swales where past logging opened the stand and caused the development of heavy crowns with forked and branchy stems.

On the slopes and ridges maple, although practically always present, is a much less important member of the tree community. Here white pine (*Pinus strobus*) is the most abundant species, although on some slopes chestnut, red oak (*Quercus rubra*), and other broadleaf species form the stand. In either case, the maple is numerically unimportant, usually occurs as single trees, and is usually removed in thinning, that the saw-timber species may be benefited. Only on those slopes and ridges which were cut clean twenty years ago is the maple considered to be a valuable species and there only because it is a better tree than the gray birch, which occupies most of the ground.

The low price of red maple boards, the frequence of the defect known as "black heart" and the heavy weight of the logs and lumber make it unusual for even a good sized tree of this species to yield saw logs which can be handled at a profit in this region. In estimating, maple of any size not too large to be split without powder is usually classed as cordwood. On the Harvard Forest, red maples larger than fifteen inches D B H are infrequent, and up to that size the choppers have little difficulty in splitting the butt cuts with wedges.

The importance of the species in the operation of the Forest led to the collection by the classes of 1912 and 1913, Harvard Forest School, of the data here presented. Most of the trees were cut by the students, but some were measured after being felled by the wood-choppers. The measurements taken on each tree were the D B H, the total height, and the mid D O B of each length of merchantable cordwood, stem and limb wood being recorded separately. The crown class of each tree, and the type in which it stood were also recorded. The number of trees measured is insufficient to give reliable results when considered for the relations of volume to crown class, or type, or for the relation of limb wood to stem wood. It is hoped to develop these relations through additional data.

Every care was taken to make the measurements represent the utilization customary in the vicinity. As a rule, bolts larger than eight inches in diameter were measured exactly four feet in length, since sticks larger than this diameter are ordinarily cut with a saw. Bolts smaller than eight inches were allowed a length of 4.2 feet, since they are usually cut with an axe, but were cubed as four foot sticks. Limbs and tops were considered merchantable whenever a four foot stick with a mid D O B of two inches or more could be

Table I

TABULATION OF DATA FOR VOLUME TABLE FOR RED MAPLE

Based on Measurements taken in 1910 and 1911 in Harvard Forest, Petersham, Mass.

D B H inches	Total Height in Feet: 25	30	35	40*	50	60	70	80	90	No. of Trees of each Diam
	Average Merchantable Volume in Cubic Feet									
2	.251 (27)	.394 (15)	.414 (2)							44
3	.588 (4)	.698 (20)	.819 (13)	.932 (12)	1.382 (5)					46
4	[4.0] 1.028 (1)	[1.2] 1.320 (1)	1.210 (7)	1.349 (10)	2.115 (13)					27
5			1.913 (6)	2.314 (15)	3.120 (12)	3.787 (7)				34
6			[6.2] 3.381 (2)	3.530 (15)	4.501 (11)	5.006 (10)	6.484 (2)			38
7				4.617 (2)	6.376 (4)	7.678 (8)	8.358 (6)			20
8				6.694 (2)	7.933 (6)	9.035 (12)	10.241 (11)	[8.3] 13.048 (1)		32
9				[9.3] 8.504 (1)	10.305 (5)	13.269 (3)	14.832 (7)	13.904 (8)		24
10					[10.1] 13.168 (1)	16.324 (4)	15.554 (5)	[10.3] 20.364 (1)		11
11					17.396 (4)	19.616 (3)	20.502 (7)	21.147 (4)		18
12						21.292 (2)	26.022 (2)	30.306 (2)		6
13					[12.6] 23.200 (1)		[12.6] 22.368 (1)	[12.6] 33.048 (1)		3
14						[14.2] 31.930 (1)	[14.0] 31.668 (1)		[14.2] 43.684 (1)	3
15								[14.6] 39.896 (1)		1
16						[16.0] 47.708 (1)		[16.0] 47.032 (1)		2
17								[17.1] 59.398 (2)		2
	Total number of Trees									311

* This class includes all trees 35.1 feet to 45.0 feet in height, and therefore some trees below 7 inches D B H which were also used in computing the averages for the 35 foot class. The averages for the trees 37.6 feet to 45.0 feet in height were as follows:

D B H	Volume
3	.958 (4)
4	1.443
5	2.581
6	3.545

secured, but here again the usual tendency of choppers to disregard possible lengths from the limbs of large trees and to use tops and limbs of small trees to somewhat less than two inches was followed.

As may be inferred from the wide range of heights for each diameter below fourteen inches (see Table I), measurements were taken in many places and in a wide variety of types, including bottom or swale, pine slope, swamp, and birch and maple coppice. Most of the trees more than six inches D B H were of seedling origin.

The volume of each tree was determined by computing the volume of each bolt by Huber's formula ($B\frac{1}{2} \times L$) and then adding the volumes of the several bolts. The volumes of trees with the same D B H and height were then averaged. These computations were checked, and partially rechecked. The averages were then tabulated with the number of trees averaged indicated by a small figure below and to the right of the figure for the volume, and when there was but one tree, the diameter shown by small figures above and to the left. Thus ${}^{10.1}13.168_1$ indicates that there was one tree of a certain diameter class and height class, the exact diameter being 10.1 inches and the volume 13.168 cubic feet.

The irregularities in the foregoing table are numerous, especially in the higher diameters in which few trees were secured. To remove these irregularities the data was plotted on cross section paper, and a curve drawn for each height class showing the volumes of trees of different diameters within that height class. In entering the data, the notation of the actual diameter of the single trees which were secured for some diameters enabled accurate plotting to be done, and the number of trees averaged to give the volumes was entered in each case so that due weight could be given in drawing the curves. The results showed some irregularities still present, especially in the seventy foot height class. The corrected data were again plotted so that a curve could be drawn for each diameter class showing the volumes of trees of different heights, and the readings from these curves were again plotted and a new curve for each height class drawn, superseding the first set of curves. The resulting readings are given in Table II.

The volumes for trees in the two inch D B H class are so small, and the habits of wood choppers in cutting up such small trees are so irregular that this diameter class was dropped from further consideration. In estimating, the possible amount of wood from trees less than 2.5 inches D B H can be considered as a margin toward conservatism.

Purely as a check on the work done so far, the volumes given in Table II were used in computing a table of merchantable form

TABLE II

VOLUME TABLE FOR RED MAPLE IN CUBIC FEET

Harvard Forest, Petersham, Mass., 1910–11

D B H inches	Total Height in Feet								
	25	30	35	40	50	60	70	80	90
	Merchantable Volume in Cubic Feet								
2	.25	.4	.5						
3	.6	.7	.8	.9	1.3				
4	1.0	1.15	1.25	1.5	2.1				
5			1.95	2.3	3.1	3.9			
6			3.0	3.5	4.4	5.2	6.5		
7				4.8	5.9	7.0	8.2	9.4	
8				6.4	7.9	9.1	10.5	11.6	
9				8.1	10.3	11.8	13.2	14.4	
10					13.1	15.0	16.5	17.6	
11					16.6	18.4	20.2	21.5	
12					20.7	22.3	24.2	25.8	
13					25.2	26.5	28.7	30.8	
14					30.0	31.2	33.7	36.5	41.5
15						36.0	39.1	43.0	
16						41.5	45.0	50.5	
17								58.0	

factors (see Table III), since it was thought that in this way any large errors would become apparent. The form factors proved to be surprisingly regular except for the larger diameters in the fifty foot height class. No adequate explanation of the high values in these cases can be given. At eleven inches, the form factor is above 500, but the average form factor for the four trees of this diameter and height actually measured is 527. More data must be collected before the results for the diameters above nine inches in the fifty foot height class can be accepted without caution, or completely rejected.

The next step in the preparation of the volume table is based on admittedly scanty data. An attempt was made to secure average figures for the proportion of wood in piles each containing the bolts from trees of one diameter class. Ordinary commercial practice was followed in splitting large bolts. Measurements of only nine piles were taken, but the resulting averages, curved, are at least

Table III

TABLE OF FORM FACTORS FOR RED MAPLE

Harvard Forest, Petersham Mass., 1910–11

D B H inches	Total Height in Feet								
	25	30	35	40	50	60	70	80	90
	Merchantable Form Factors								
3	464	453	457	459	530				
4	477	438	411	429	481				
5			429	420	454	476			
6			437	446	448	442	473		
7				449	441	436	438	439	
8				458	453	434	421	415	
9				458	466	446	427	407	
10					480	458	432	403	
11					503	465	437	407	
12					527	473	440	411	
13					547	479	445	418	
14					561	486	450	427	431
15						489	455	438	
16						495	465	452	
17								460	

approximately correct for average conditions on the Harvard Forest. The influence of crown class was found to be very strong in even the small amount of work done, since overtopped and intermediate trees usually have few limbs and the bolts are fairly smooth, while dominant trees often have heavy crowns which yield knotty and crooked bolts. One pile made from overtopped six inch trees had over seventy per cent wood, although the average for this diameter was well below sixty per cent. In estimating, this variation should be kept in mind, especially where suppressed or intermediate maples are to be taken out of a pine or chestnut stand in thinning. The proportions used are given in Table IV.

Table IV

PER CENT OF WOOD IN PILES OF RED MAPLE CORDWOOD

Based on 9 piles of 2 to 4 cord feet each. Harvard Forest, Petersham, Mass., 1910–11

D B H of Trees	Per cent of Wood in Pile	D B H of Trees	Per cent of Wood in Pile
3	52.5	11	68.0
4	53.6	12	70.0
5	54.9	13	71.5
6	56.2	14	73.0
7	58.0	15	74.0
8	60.2	16	74.6
9	62.8	17	75.0
10	65.5		

Table V

VOLUME TABLE FOR RED MAPLE IN CORDS *

Based on Measurements taken in 1910 and 1911. Harvard Forest, Petersham, Mass.

D B H inches	Total Height in Feet									Basis. No. of Trees
	25	30	35	40	50	60	70	80	90	
	Merchantable Volume in Cords									
3	.009	.010	.012	.013	.019					46
4	.014	.016	.018	.022	.030					27
5			.028	.033	.044	.055				34
6			.042	.049	.061	.072	.090			38
7				.065	.079	.094	.110	.127		20
8				.083	.102	.118	.136	.150		32
9				.101	.128	.147	.164	.179		24
10					.156	.179	.197	.210		11
11					.191	.211	.232	.247		18
12					.230	.241	.270	.288		6
13					.275	.290	.314	.336		3
14					.321	.334	.359	.391	.444	3
15						.380	.413	.455		1
16						.434	.471	.529		2
17								.604		2
									Total,	267

* This volume table is computed with the standard cord of 128 cubic feet. In places where extra height is required to allow for shrinkage, the volumes given should be reduced proportionally.

The cubic volume for trees of each diameter and height class given in Table II was then divided by the percentage for the corresponding diameter class given in Table IV, and the quotients multiplied by 100 to find the space, in cubic feet, occupied by the tree in a pile. This figure was again divided by 128, and the quotient taken as the fraction of a cord of merchantable wood in the tree. The volume table was then rewritten in cord measure, and is given as Table V.

The custom on the Harvard Forest is to measure cordwood promptly after it is cut, using as the unit of measure the standard cord (a pile four feet wide, four feet high and eight feet long), containing 128 cubic feet. The wood is usually sold without remeasurement. The foregoing table has been made for use under these conditions, and the volumes given should be discounted for use in localities where choppers are required to make their piles four feet four inches high to allow for shrinkage. This discount may also be made by using the table as it is, but reducing the total indicated volume of the stand. A discount of ten per cent would be liberal, and eight per cent should ordinarily be sufficient.

Possibly the following general statement may be remembered for use when the table is not at hand.

Red maples of good height for their diameters should run: —

If	4	inches	D B H	about	50	trees	to	the	cord.
If	6	"	"	"	20	"	"	"	"
If	8	"	"	"	9	"	"	"	"
If	10	"	"	"	6	"	"	"	"
If	12	"	"	"	4	"	"	"	"
If	14	"	"	"	3	"	"	"	"

FIRE PROTECTION

RICHARD F. HAMMATT, B.S.F. 1906

SOME six years' work, mostly administrative, in the United States Forest Service, has impressed me more and more with the vital importance of the fire problem, particularly from the lumberman's and forester's view points.

To the progressive lumber or pulp concern, or the forester going into either private or Government administrative work, fire protection is, in a way, the basis of all operations. What concern can hope to get a second cut from its logged over lands, if they are burned over every five or ten years? What good does it do for the forester to determine quality classes or rate of growth, to figure on yield per acre, rotation, or annual cut, if continued fires are going to upset all his calculations and burn all his work? The prospective forester *must* understand that it is up to *him* to so protect the holdings in which he is working that his other work will be of some value.

There are now a number of schools and colleges in the United States giving instruction in lumbering and forestry. There are, annually a large number of men attending such schools. Do these men realize how much more true fire protection means than getting men, supplies and tools to a fire as soon as it is reported, and then putting it out? Did it ever occur to you that, as the man in charge, you should know, not only every square mile of the physical features of your country, but that you should know, too, the climatic, moisture and wind conditions, and the amounts and kind of brush and debris as well as the timber?

Nearly every one realizes, of course, that time, money, and loss of life and property can be avoided by roads, trails, and telephone lines. Did you ever try to work out a complete and *economical* plan for such improvements covering a broken area of one and one-half million acres? You know that to get the fullest benefit from such a system there must be a force of men placed at strategic points throughout the dangerous season. Did you ever try to pick out such places over a big area ? And did you ever plot and compare curves showing the area burned over per week throughout the fire season, the number of fires per week of the season, and the number of men per week of the season necessary to give the proper protection, and at the same time keep costs to a practical minimum ?

Fire protection is undoubtedly a big and vital question, so vital that more time should be given to it in schools and colleges than has been done in the past. It is true that *fire fighting* cannot be taught. But fire fighting is secondary to fire protection and fire prevention and to a large extent these can be taught.

In any course on fire protection, prevention should also be considered. Fire prevention is largely a question of publicity, organization, personality and legislation.

No matter how good the local or national legislation is, it may be practically nullified unless the public is brought into sympathy with the objects sought. This can best be done with local residents by personal contact, and with other users of a forest area by publicity. We should all recognize the fact that we must get the public interested in our work. To do this, interesting and instructive articles and so called news items must be prepared. The importance of this phase of the work should not be overlooked.

In fire protection much preliminary work is necessary. Fortunately the members of the Harvard (and several other) schools should have, by now, much of the preliminary data.

There is required, first, as intimate a knowledge as is possible of the area to be protected, its topography, climate, prevailing winds, moisture conditions, forest conditions (including brush, debris, especially valuable sub areas, etc.), its existing roads, trails, railroads, telephone lines, towns, lumber, and other camps and ranches; the principal area used by campers, hunters, and fishermen, and the main routes used by them in entering and leaving the area under consideration.

In addition there should be obtained a history of recent fires, their location, area, causes, damage done, and methods and cost of fighting them. This information should be tabulated and summarized. As much of this information as is possible should be shown on a topographic base map of the area.

Right here should be emphasized the necessity, (*first*) for careful and detailed plans and, (*second*) the putting of those plans on paper. The man who doesn't plan this part of his work carefully and thoroughly ought to be given a job requiring a strong back and a weak mind, rather than vice versa. And the man who, knowing that he personally can't see to all the details of every emergency that may arise, doesn't, after making them, put his plans on paper, should be treated only a little more leniently than the first man.

All this, and much more information is but preliminary to the actual plan. Next should come the determination of the number of men needed to insure protection, the points at which they should be placed and the lengths of time they should be employed. Will a system of stationary lookouts on high and commanding peaks serve, or do you need mounted patrolmen? Should you have a combination of the two or do you need moving lookouts? Should the patrolmen stick to the ridges in order to see over a big country or should they be in the main-used canyons and on the main-travelled roads and trails to keep track of hunters, campers, and fishermen? Have you got commanding peaks or ridges that can be used or trails that will allow patrols to travel in the right places? Shall the patrols go on foot, horseback, or should they use motorcycles or automobiles? When does the fire season begin — when does it end — and what is the most dangerous season? Which will give you the best protection, ten men from the beginning to the end of the season (say five months) at a total cost of $3750.00 or one man for five months, two for four months, six for three months, nine for two months, and one for one month. In the second case it is quite probable that you are getting better protection with the same amount of money by employing twenty men for short periods instead of ten men for longer periods. On the other hand, it may be possible that conditions are such that a number of comparatively long term men must be employed.

If lookouts are used there must be means of quick transmission of messages, either telephone, telegraph, heliographs or a wig wag system. The patrols should be able to get messages to headquarters quickly and they must be able either to get men and supplies themselves or have them sent in without delay. What methods of communication are available and what more are essential ? When should they be built and will their cost pay in the long run ? Have you made arrangements for the lookouts to live on top of the peaks or will they camp below somewhere where they will lose two hours through the day and all the evening, night, and early morning ?

It is essential that your patrols keep as much as possible in touch with headquarters, and you or some one, should know where to get them at any time of the day or night. Are they travelling their particular country promiscuously or have you laid out for them definite routes, with schedules, so you will know where to intercept them if necessary ?

Does each man of your protective force (outside of the stationary lookouts) know where he can get men, tools and supplies quickest for any fire that may occur ? How is he to provide transportation? Is there a store at which provisions can be obtained and does he know how many provisions to take without packing an extra 100 or 200 pounds ? How many extra men can he get, where can he get them, and how soon can they reach the fire, if it is a big one and he needs a big force ?

These are a few of the questions which nearly every one of you will have to consider. The answers will be different in nearly every case, but if you will consider the problem for a given area now, it will help immensely when you start out into actual work of your own.

NOTES ON THE CHESTNUT BARK DISEASE (*DIAPORTHE PARASITICA*, MURRILL) IN PETERSHAM, MASS.

J. Kittredge, Jr., 1913

The following data were collected in October and November, 1912, at Petersham, Massachusetts. The object of the study was to determine the present status of the chestnut bark disease in and about the Harvard Forest and to secure any possible information about the habits and appearance of the fungus which might indicate the means by which it is or is not distributed.

The disease was first noticed in Petersham in the fall of 1910 by Professor J. G. Jack of the Harvard Forest School, along a road not over a mile from the School and about three and one-half miles north of the village of Petersham. In August and September, 1911, Professor A. H. Graves, then in the Bureau of Plant Industry, found infection at several places in and about Petersham, particularly along the Athol Road. At that time he marked infected trees in several localities and carefully examined others near them, noting whether they were probably infected or apparently sound. The locations of a number of these infections were pointed out to the writer by Professor E. E. Carter of the Forest School.

In this study the infection was viewed from the forester's standpoint, with little or no reference to the morphological or physiological characteristics of the disease. At the time of the study, only the winter fruiting bodies were in evidence.

In the first part of the study, data was collected as follows: All trees showing any evidence of infection were first classified in three groups: —

I. Trees surely infected (with the fruiting bodies developed).

II. Trees probably infected (with dead branches and persistent dead leaves or burrs or badly sunken bark).

III. Suspicious trees (with the persistent leaves or sunken bark less markedly developed than for Class II trees).

Trees which were apparently uninfected were entirely disregarded. For all trees included in the above tree classes, the following data was noted: —

1. Careful geographical location.

2. Origin, seedling or sprout.

3. Diameter at breast height.

4. Crown class; whether dominant, co-dominant, intermediate, overtopped, or suppressed.

5. Distribution of infection about known centres, and relations of crown and distance between infected specimens (numbered and oriented sketches).

6. Location of trees relative to site, aspect, forest type, and density of surrounding stand or degree of isolation with history of its cause.

7. Probable length of time since infection started.

The field work consisted in the inspection of trees, along roads, on strips through the woods, and around infections which had been previously reported. After some data had been secured in this way, the rest of the time was devoted to a detailed study of one stand on the Harvard Forest, which will be described later.

The infection is now almost universally distributed in the town of Petersham. Surely infected trees were found from the Athol line on the north to North Dana and New Salem on the west, and two miles south of the village toward Barre. The region to the east of the village was not examined.

Origin seems to have had no effect on the susceptibility of chestnut to the disease. The data obtained showed that the total number of infected sprouts in Classes I and II exceeded the total number of infected seedlings in the ratio of two and one-half to one, but this difference is easily accounted for by the predominance of sprouts over seedlings in the whole chestnut growth of the region. When all trees are included as a basis of comparison, the ratio is about three and one-half to one. This is, however, in a stand typically of sprout origin. On the special plot, the insignificance of the influence of origin is more evident, for of 219 trees of seedling origin, 32 (14.5 per cent) were surely infected, and of 747 trees of sprout origin, 97 (13 per cent) were surely infected. Trees in Classes II and III have been omitted from consideration here because they were so numerous in this stand, where so many sources of infection were in close proximity that origin could have no effect on their susceptibility in any case.

Proximity to roads and highways has no apparent effect on the distribution of the disease. It occurs right next to the roads on isolated roadside trees, but on the other hand, the worst infection examined was more than one-quarter of a mile from any road and fully a mile from the nearest highway used by automobiles. Whole stands, more isolated from roads than this one, are rare in the vicinity.

The relation of appearance of fruiting bodies to side of trees was also studied. When the infection is three or sometimes only two years old, it has almost always girdled the tree, so that the fruiting bodies appear on all sides of the stem. If, however, the infection is more recent, they usually appear on the south or southwest side of the tree, probably owing to the greater warmth of the sun's rays on that side. In two cases where the trees were heavily shaded to the S. W., the fruiting bodies were observed only on the unshaded N. E. side. Of 112 trees, showing the fruiting bodies only on one side, the different sides were represented as follows: —

	S. or S W	N.	E.	W.	Total
Number of trees	93	3	5	11	112
Percentage of total	83	3	4	10	100

Grouping the trees noted in three inch diameter classes, it appears that trees from three to six inches D B H show at least the matured results of infection quickest and that trees below six inches are more liable to infection than those of larger diameter. The figures somewhat exaggerate the actual conditions owing to the predominance of the number of small trees among those examined, but the numerical ratio of small to large infected trees appears distinctly larger than the ratio of all small chestnuts to larger ones on the areas examined.

The fungus will as readily attack a healthy dominant tree as a feeble suppressed one. Frequent cases were noted in which trees grown in the open pasture lands or along roadsides bordered by meadows, under the best light conditions for vigorous and complete crown development, were badly attacked. The figures seem even to indicate that it prefers the dominant trees, for of the 231 surely infected trees, sixty-three per cent were dominant or co-dominant, seventeen per cent were intermediate, and twenty per cent were over overtopped or suppressed; and of the 524

INFECTION BY DIAMETER CLASSES

Diameter Class	Surely Infected		Probably Infected	
Inches	Number	Per cent	Number	Per cent
0 –3	59	26	261	50
3 –6	106	46	223	42.5
6 –9	52	22	33	6
9–12	11	5	5	1
Over 12	3	1	2	0.5
Totals	231	100	524	100.0

probably infected trees, forty-three per cent were dominant or co-dominant, twenty-three per cent were intermediate, and thirty-four per cent were overtopped or suppressed.

No consistent relation between centres of infection and more recent infection from those centres could be established, although it was very evident that some areas were more heavily infected than others. Descriptions of the distribution about two rather distinct centres will best illustrate the lack of a definite relation as to direction.

1. A seed tree left on flat after cutting in 1909; now badly infected and dying. There is an alder swamp to the west and three year old sprouts over the open country to the S. E., and N. W. Three surely infected sprouts, which might under the circumstances have been infected by wind dissemination from this tree, are situated, (*a*) 45′ north, (*b*) 50′ east, and (*c*) 115′ S. E. There is probable infection scattered over much of the area.

2. Another flat, three hundred yards northeast of the first one. A mixed hardwood and pine stand which had been thinned and was surrounded by pure pine and swale. This case shows a distribution about centres to the W., S. W., and N.

In neither case is there any possibility that the spores could have washed from the central tree to the others. The diseased trees on the special plot show further examples of centres and the surrounding infection with no constant relation between the two. Certainly in these cases, with the possible exception of the first one, there is no distinct spread to the N. E. or S. E. as might be expected if the fungus spores were primarily distributed by the prevailing westerly winds of the region.

There is always the possibility in this connection that it is not distribution about centres at all which we see. The centres of infection are not always easy to determine. Having been determined, the question rises, are the nearer surely infected trees, *i. e.*, those producing spores, the result of infection by spores which were produced on the original tree ? In the majority of cases the writer thinks not, but rather that they were infected before the supposed centre of infection had reached the point of producing spores. This seems the more plausible when badly infected, isolated trees are found with no other chestnuts within one hundred feet and those that are nearest apparently sound.

Petersham is in a transitional forest region where the northern pine overlaps the southern New England sprout-hardwood region. The types are usually distinct. Thus, there is an excellent opportunity to study chestnut in a variety of surroundings as regards type and to see if trees in one type seem more immune to the disease than those in another. Chestnut, of the forest trees, is only exceeded in abundance by white pine and red maple. It occurs on any well-drained soil, either in stands, largely of sprout origin, or at the other extreme, isolated in the open pasture land which is slowly seeding in to pine or even in stands of ninety per cent pure pine. The sprout stands may be of widely varying mixtures of hardwood and chestnut, or they may contain chestnut up to sixty per cent of the stand by number or a much larger percentage of the dominant trees. Trees and stands of all ages up to eighty years are represented and scattered individuals may be considerably older.

There appeared to be no relation between susceptibility to attack and the types in which chestnut occurred. Trees with fully developed fruiting bodies were found under all the conditions in which chestnut grows in the region, — in the open pastures; along roadsides; isolated trees in pine stands; isolated trees in stands of red maple, gray birch, and aspen; in mixtures of red oak, chestnut, ash, and maple; and in stands classified as chestnut slopes. Certainly no type provides immunity from the disease, although the data collected indicates, as will be shown later, that presence in or proximity to certain types tends to increase the liability to infection.

The frequent discovery of dead or badly infected trees in or near stands of pure pine or pine in mixture led to the detailed examination of all the chestnuts over an area where infection had been found by Professor Graves in 1911 and where many trees are now dead or very badly infected. The stand was a sprout-hardwood slope, with easterly aspect, in which chestnut formed thirty per cent to forty per cent of the stand. It was bounded on the north by twenty year pine; on the west by a strip of twenty year pine with open, grassy land beyond over the crest of the hill; at the foot of the slope to the northeast, there was a patch of pine and hemlock and southward, a maple swale followed the brook. Five fifty foot strips were run down this slope, parallel to the north boundary, the first three adjacent to the pine and the last two at intervals of one hundred feet. Every chestnut on these strips was inspected and placed in one of four classes, Class IV to include all apparently uninfected trees. The rest of the data was noted as previously described. The strips are numbered successively from the north at the edge of the pine to the south.

Strip number	1		2		3		4		5	
	No. of Trees	Per cent	No. of Trees	Per cent	No. of Trees	Per cent	No. of Trees	Per cent	No. of Trees	Per cent
Class I	47	*27*	30	*19*	24	*12*	19	*9*	9	*4*
Class II	46	26	50	31	73	38	101	46	71	31
Class III	38	22	46	28	81	42	76	34	76	33
Class IV	44	25	35	22	15	8	25	11	73	32
Totals	175	100	161	100	193	100	221	100	229	100

The progressive decrease in the percentage of surely infected trees as you go further from the pine at the north edge is very striking.

The results shown in Classes II, III, and IV, although somewhat contradictory, are comparatively insignificant, because the large number of spore-producing trees in the stand for the last year or more would be sure to cause recent infection in most of the chestnuts on the area through any agency. Hence, they are of little value as indicating the primary means of distribution to new localities. To further test this same idea, the data from this area were divided into three strips, perpendicular to the first five, so that the first was adjacent to the pine at the top of the slope, the second, along the central portion, and the third, along the foot, next to the hemlock and maple swale. These strips cover approximately one hundred and fifty feet in width.

Strip number	1		2		3	
	Number of Trees	Per cent of total	Number of Trees	Per cent	Number of Trees	Per cent
Class I	61	17	20	8	51	17
Class II	166	47	82	32	114	37
Class III	91	26	124	48	101	33
Class IV	35	10	32	12	41	13
Totals	353	100	258	100	307	100

In this table again, the number and percentage of surely infected trees are greatest in the strips adjacent to the pine or swale.

Outside of this area also, the Class I trees were found most frequently near coniferous stands. Since notes were made on the distance of infected specimens from coniferous stands only in the latter part of the study only sixty-three trees are included in the following table: —

Location		In pure Pine Stands	Within 100' of Pine	100'–500' from Pine Stands	500'— from Pine Stands	Totals
Class I	Number of Trees	4	28	20	11	63
	Per cent of Total	6	44	32	18	100

This data as a whole would seem to show that it is more than mere coincidence that the disease occurs more frequently in or near coniferous stands. The most plausible and, so far as the writer can see, the only reasonable explanation of such a distribution is by bird agency. It is a well-known fact to any one who has ever watched the habits of birds that they are more abundant on the borders of woods, especially evergreen woods, or where there is a change of type, as at the edge of a swampy tract. If then, both the birds and the disease are more abundant at the edges of coniferous stands where the hardwoods or chestnut adjoin them, and no other agency will account for such a distribution of the disease, why should the two facts not be cause and effect ?

The data on the location of fruiting bodies on the tree as regards height seem to point to the same conclusion. Actual notes taken in the latter part of the field work show that when the infection was still comparatively local on the trees, it usually had started on the main stem, somewhere in the middle third of its height. The writer feels certain that, if further data on this point had been secured, it would have shown the same results. The data secured are as follows: —

Position on Tree	Middle third	Above	Below	On a branch only	Total
Number of cases	28	1	5	3	37
Percent of total	76	3	13	8	100

In three cases, in which the trees were climbed to examine infections which were confined to branches, the fruiting bodies were on the upper sides of the branches only. In only two cases did the infection seem to have started round a wound. These figures again indicate a distribution by birds, and primarily by the creeping birds, such as the creeper, nuthatches, and woodpeckers, which spend most of their time on the trunks and big limbs. Although these birds are permanent residents in Petersham, there is a decided migration of them in spring and fall as those that are residents further north or south pass through. This would explain the rapid spread of the disease over long distances and also its peculiar local distribution.

In order to discover any possible effect of distribution by wind, the groups of sprouts, in which not all of the trees were surely infected, were considered separately. This furnished data for the following table which show the relative frequency with which the infected sprouts were found in different positions in the groups.

Position in group	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Central
Number of cases	2	4	3	12	6	5	2	4	2

These results surely show that a prevailing southwest or northwest wind is not the prime factor in the distribution of the spores.

The disease is a serious menace to the future production of chestnut in the region. Of about 700 trees examined (counting groups of sprouts as single trees), 122 or seventeen per cent had infection which seemed to be two or more years old; nine or one per cent showed a probable three year old infection. Several trees which were examined fifteen months previously by Professor Graves and considered sound at that time are now badly infected. On the special tract, where the infection was as bad as any that the writer saw, in a stand with a large proportion of chestnut, the results were as follows: —

	Number of Trees	Per cent of total
Dead †	28	3
Class I	129	13
Class II	341	35
Class III	317	32
Class IV	192	20
Totals	979	100

From these figures, it is evident that the chestnut bark disease is a very serious and imminent menace in this region. Estimating conservatively and judging from the fact that trees, dead at present, have not been infected more than three years, thirteen per cent of the trees in this stand will be dead in two years and twenty-five per cent to thirty per cent in three years.

† Dead trees are also included in Class I.

From the foregoing data, it is possible to sum up the following tentative conclusions as to the habits and status of the fungus. It is fully realized that the basis for most of these tentative conclusions is very meager.

1. The disease is well established and widely distributed in the town of Petersham.

2. Sprout or seedling origin has no effect on the susceptibility of chestnut trees to the disease.

3. Proximity to highways and roads has no apparent relation to the infection.

4. The fruiting bodies appear first almost always on the S. or S. W. sides of the trees.

5. Trees over six inches in diameter at breast height are somewhat more resistant to the disease than those below that size.

6. There is no definite direction of spread about centres of infection.

7. The location of infected trees in partially infected groups of sprouts shows that wind is not the prime factor in the distribution of the spores.

8. Dominant trees are as likely if not more likely to be infected than suppressed ones.

9. Lesions usually appear first in the middle third of the main stem.

10. The disease occurs in any type where chestnut forms a part of the stand. Infection is more abundant, however, near the margins of coniferous stands, which indicates that birds may be a very important, if not the primary agent, in its distribution.

11. At the present time, the worst infection seen shows thirteen per cent of the chestnuts badly infected so that they will die in two years.

COLLECTION OF LODGEPOLE PINE SEED ON THE LEADVILLE NATIONAL FOREST

J. Edward Martin, M.F. 1908

Considering the large areas on the Leadville National Forest that have been burnt or cut over, there is no more serious problem confronting the Service than that of reforestation. In most instances, these areas are adjacent to timber line and are above the main bodies of timber so that they do not receive the benefits of the prevailing winds regarding seed dissemination. These areas are potential timber land and at one time supported large bodies of merchantable timber. Owing to the altitude and soil conditions, this land is available for no purpose, excepting at the present time it has a nominal value for grazing.

Many important rivers as the Arkansas, Blue, Middle and South forks of the Platte, together with their principal tributaries, have their origin in the Forest. Practically all of the ranchmen in and adjacent to the Forest, together with those in the valleys below are dependent on the water from these rivers for irrigation purposes. With the agricultural land of the State increasing, water values will also increase in due proportion, as the agricultural value of the land is dependent upon the mountain stream flow. By an extension of forest growth on these denuded areas, a great deal will be accomplished in meeting the above purposes in bringing about a constant and maximum period of water flow when it is most needed for irrigation.

Perhaps the most important question concerning forest extension work is the collection of seed. The extent to which this work is carried on is largely dependent on the supply of seed that is available for this purpose. This problem is one which requires considerable foresight and preparation on the part of the Forest officers. We should always be familiar enough with the Forest, and especially every ranger with his district, to determine whether there is a sufficient crop to make seed collecting practicable.

On the Leadville most attention is given to the collection of lodgepole pine. Although other species as yellow pine, douglas fir, engelmann spruce, etc., are available, we are not so sure of a successful crop. A large annual crop of lodgepole pine seed is conceded a certainty and owing to its wide distribution and accessibility, a large amount of seed can be collected every year. At the high altitudes no species is considered more favorable for reforestation, and from a protective standpoint, it is considered one of our most important trees. Owing to its great variety of uses, it is also an important tree for commercial purposes.

Two years are required for lodgepole pine to mature their cones, consequently, the small green cones that are seen in the spring form the basis upon which to determine the crop expected in the fall. The flowers of the lodgepole pine are orange red in color, and the staminate are in short crowded spikes, while the pistillate are clustered or in pairs on stout stalks. The blossoms of this species are conspicuous in May or June. By July 15, the staminate flowers have withered or disappeared, and the pistillate flowers have begun to develop into growing cones, so that there is no difficulty in determining the crop. By considering the density of the stand, the distribution of the crop, and the area over which the crop appears to be good, we have a basis on which to estimate the amount of seed that will be available.

Prior to 1910, all the seed that was used for reforestation work was sent here from the other Forests. The first extensive seed collecting on the Forest was done in the fall of 1910 when crews were working adjacent to Leadville, Dillon, Buena Vista and Twin Lakes. A total of 678 bushels was collected at a cost of $1.431 per bushel, or $4.368 per pound. During the field season of 1911, all the work of collecting this species was concentrated at Dillon. Although all the cost data for last year's collecting is not available at the present time, we are confident that it will be greatly reduced and should not exceed over $2.50 per pound.

In general seed collecting starts about September 15, although in some instances, collecting might start a little earlier. On this Forest, the last cones are generally secured about November 15. In this locality the length of the cone collecting season is generally determined by climatic conditions.

Cones are generally obtained from squirrel hoards, climbing trees, and lumber cuttings. Only the first two methods have been employed on this Forest.

Squirrel Hoards. — In collecting cones, the greatest success has come through the observation of the squirrels in locating their hoards and obtaining the cones. As these little denizens of the forest use the same locations every year, their hoards are easily recognized by the old scales that are generally heaped around the hoard. These hoards can be classified as buried and exposed.

In the first instance, the cones are found in the old hoards that have been used for several years, and this year's crop is generally buried under the old hulls. They are generally found along old logs, accumulations of poles, and in rock crevices. Another method of burying them is to put from four to six cones in small pockets in the ground or rotten logs. The exposed hoards are found along the underside of logs, poles, rocks, and at times on the top of the ground.

The amount of cones that have been found in hoards run from one to six bushels, while the maximum amount obtained on the Forest from one hoard has been fifteen bushels. In walking through the Forest during the fall, one observes that where squirrels are abundant there is a store of cones around practically every log. With such an abundance of cones available, there is very little likelihood of collectors securing the entire supply.

Climbing Trees. — During the fall of 1910, this method was applied for experimental purposes. One method employed was that the men stood on the ground and collected the cones from the lower branches, while the other consisted in climbing the trees where the tops were heavily laden with cones. The latter can be worked to best advantage by starting at the top and working down, as the clusters on the fruiting branches can be easily seen and any cones that are lodged can be secured. Owing to the great damage that results to the young trees, it would be impracticable to continue this method of collecting cones to any great extent.

The system used in collecting cones, as applied here, can be classified as ranger help and as additional help. Under ranger help is included only those cones that are collected by the rangers working independently and at such times as their other work will permit. Additional help may be classified (*a*) by paying a contract price per bushel of cones, and (*b*) by paying men working by the day, independently or in parties. During the fall of 1910, when all three methods were used on the Forest, the cost per bushel for collecting cones was $0.706, or $2.33 per pound. During the field season of 1910 the contract price for collecting cones at Dillon was forty-three cents per bushel.

With a supply of cones on hand, the next step is to haul or pack the cones to the treating plant or to the railroad station where they are shipped to the plant. Those that are collected by contract and the ranger force are hauled and packed at no additional expense. In the fall of 1910, cones that were collected at Twin Lakes had to be hauled fifteen miles to Buena Vista, while those collected adjacent to Leadville, had to be hauled six miles to the railroad station and then shipped thirty-six miles to the plant at Buena Vista. The average cost per bushel for hauling cones in 1910 was $0.075, or $.248 per pound. This figure will be reduced to some extent by last fall's work as the collecting was practically all done by contract and ranger labor.

With the active field season brought to a close by climatic conditions, the rangers have ample time to extract the seed from the cones. Two buildings were used for seed extraction in 1910, one at Dillon and the other at Buena Vista. Both buildings were equipped practically the same, except that the ranger at Dillon made a revolving device to shake the seed from the cones.

At Buena Vista a three room house was used, in which two rooms were used for drying and the other for storing the cones. In these two drying rooms were fifty-seven trays, 3×5 feet, covered with one-half inch mesh wire netting. These trays held on the average of one and one-half bushels. At Dillon only one room was used for drying purposes, which held sixty-one trays, 2×4 feet, averaging three-quarters bushel per tray.

The trays in both plant houses are arranged in racks along the sides of the room, being four inches apart, with the upper and lower trays approximately twenty inches from the ceiling and floor respectively. Sheets are then spread on the floor to catch the seed. With the trays properly arranged, a fire is started in the stove. The average temperature at the Dillon plant to open the cones was 120° F., while 100° F. was necessary at Buena

Vista. The average time required to open the cones was four days, this depending to some extent on the weather. The average number of cones extracted per day was ten bushels at Dillon and five bushels at Buena Vista.

With the cones open, it is necessary to remove the seed from the cones. One method employed was to shake the cones in screens by which two men were able to treat twenty bushels in one day. If the cones are entirely open, the seed can be removed in this way, otherwise it is too slow. At the Dillon plant the seed were removed with a revolving churn. The ranger in charge of this work reported that it took from five to twenty minutes to run a bunch of cones through this process, and that he treated forty-five bushels in one day. By this process there is no difficulty in removing the seed from the cones.

With the seed extracted, they are then cleaned by rubbing or beating in sacks, and then running the seed through a fanning mill. This method has proven the most efficient.

The average cost of extracting and cleaning seed was sixty-five cents per bushel, or $1.79 per pound. The extraction and cleaning of last year's crop is not complete at the present time, but we are certain that the cost of 1910 will be reduced.

The seed are then suspended in sacks in a cool dry cellar or attic where they are stored away until spring, when sowing operations begin. Care should always be taken to guard against seed destroying animals and changes in air temperature and air moisture.

Before sowing the seed in large quantities, it is very essential that the seed should be tested to determine its germinative power. Seed testing must be done very carefully to be of any value, and in order that reliable data may be obtained it is necessary to have this work done at the Fremont Experiment Station, where there is special equipment provided for this purpose. The average germination test of all samples of seed collected in 1910 was .666%, while the average number of seed per pound was 70,000. The average test of seed of the 1911 crop, as far as returns have been received, is .661% with the average number of seed per pound 95,000. It has been found that a bushel of cones will yield .33 pound of seed. Approximately 2,100 cones are necessary to produce one pound of seed, while 360 cones are required to make one bushel.

RECONNOISSANCE ON THE TAHOE NATIONAL FOREST

KNOWER MILLS, M.F. 1911

THE aim of the Forest Service is to manage each forest in such a way that its products will, as soon as possible, be made continuously available to the people who need them. In accordance with this purpose reconnoissance work, as a step in the direction of complete working plans, is chiefly concentrated at present on Forests where a large amount of timber sale business is expected. The Tahoe National Forest in California is one of these.

During the summer of 1911 the writer was employed in reconnoissance work on the Tahoe. An important part of the work consisted in securing the necessary estimates and maps for one of the largest government timber sales in District 5. The recent change in Forest Service policy with regard to large sales, permitting the disposal of mature timber on a large scale, with permits providing from five to twenty years for the removal of the timber, has resulted in several sales for large amounts. Few long term sales have hitherto been made on account of the difficulty of foretelling stumpage rates which would be fair to the Government and to the purchaser throughout the life of the contract. It is worth noting that the sale of 73,000,000 feet of timber which was recently concluded on this Forest initiates a new method of establishing future stumpage rates, providing for readjustment at five year intervals, to conform with current lumber values.

The Tahoe Forest is situated on both sides of the main divide of the Sierras in California and Nevada. It has a gross area of 1,272,470 acres, but is so much broken up by patented lands, as a result of the grants of alternate sections to the Southern Pacific Railroad, that the amount of actual forest land within the forest boundaries is only about one-half the gross area. This "checkerboard" condition, which complicates timber sale policy and grazing management to a considerable extent, is felt strongly in reconnoissance, since it requires the running of a large amount of "dead line" between the isolated subdivisions of government land and makes it possible to cover only a relatively limited area from one camp.

The summer work was in two main forest types — the jeffrey pine type, which is characteristic of the high plateau region on the east slope of the Sierra Nevada Mountains at this latitude, and the red fir type, which is found on the upper slopes and ridges of the main divide of the Sierras. These include several more or less definite sub-types in which subordinate species enter into the composition of the stand. Work was also done in two other pure types — lodgepole pine and black hemlock, which are less important commercially.

Jeffrey Pine Type. — The general altitudinal range of this type is from 5,000 to 7,500 feet on south exposures, and from 5,000 to 6,200 feet on north slopes. The essential trees are jeffrey pine (*Pinus jeffreyi*) and white fir (*Abies concolor*). Other less important species of occasional occurrence are sugar pine (*Pinus lambertiana*), incense cedar (*Libocedrus decurrens*), western juniper (*Juniperus occidentalis*), red fir (*Abies magnifica*), and lodgepole pine (*Pinus contorta*). In a few localities western yellow pine occurs with jeffrey pine. From the forester's standpoint, these two species are practically identical.

Two sub-types, pure jeffrey pine and jeffrey pine-white fir can be distinguished. The former occurs on south exposures and at lowest elevations in dry situations. The stand is a very open, old selection forest composed mainly of over-mature and mature trees with a smaller proportion of the younger age classes. The density of the stand is determined by the root struggle for moisture rather than by competition of the crowns for light. The average stand is about 10,000 B. F. per acre. Growth is very slow. Forest growth on the east slope of the Sierras presents a strong contrast with growth on the west slope.

The jeffrey pine-white fir sub-type occupies a transition zone between the pure jeffrey pine sub-type and the red fir, or sub-alpine type. It reaches best development on north slopes between 5,000 and 6,200 feet altitude. A typical proportion of species in this type is sixty per cent jeffrey pine and forty per cent white fir.

The density here is often determined by crown competition for light rather than by root struggle for moisture. The average yield is about 18,000 B. F. per acre. Reproduction is mainly fir, occurring in groups beneath the large trees; jeffrey pine reproduction, on the other hand, comes in only in openings but it outgrows fir in the seedling stage.

Management in the jeffrey pine type aims to favor jeffrey pine within the limits of the best growth. A modified shelter-wood system is used with the aim of providing adequate pine reproduction, conserving the factors of site and securing a second cut in thirty years. It is not advisable to open up the stand heavily on account of deficient soil moisture and the competition of brush.

Red Fir Type.—Red fir is the chief species. The general altitudinal range of the type is from 7,500 feet on south exposures, and from 6,500 feet on north slopes up to the summits. Although red fir sometimes occurs pure, it is more often associated with white pine (*Pinus monticola*), white fir, black hemlock (*Tsuga mertensiana*) and lodgepole pine, in various mixtures and proportions, forming several more or less definite sub-types. White fir generally predominates at the lower limits of the type but is less numerous at higher altitudes. The stand is a selection forest, with a tendency toward grouping of age classes. The average stand is about 25,000 B. F. per acre, but the yield shows a wide variation in accordance with local conditions. The maximum stand is about 125,000 B. F. Such large yields occur, however, only under the most favorable conditions and on restricted areas. Red fir reaches its best development on deep moist soil in sheltered situations.

The chief consideration in marking is protection of the remaining stand from damage by wind. A group selection system is used in management, favoring red fir. Watershed protection is an important consideration in marking.

Both the red and white firs are of great value as pulp material. A sale of 5,500 cords of these two species was made last year on this Forest to a company which uses 28,000 cords of red and white fir timber per year. The products are a high grade of wrapping paper and tissue paper.

Lodgepole Pine Type.— This type, which generally consists of pure lodgepole pine, is governed in distribution by soil moisture. It occurs only around the edges of mountain meadows, along the banks of streams, and in moist pockets in the side hills. The average stand is about 5,000 B. F. per acre. Mixtures of lodgepole pine with red fir, white fir and hemlock are frequently found.

Black Hemlock Type.— Pure hemlock occurs only on high peaks at altitudes from 7,500 feet to the summits. The average stand is 12,000 B. F. to the acre. The type is at present of little value commercially but is valuable as a protection forest.

The Forests of the West Slope.— Forest conditions on the west slope at elevations from 3,000 to 5,000 feet, where reconnoissance is being carried on this winter, offer a strong contrast to conditions on the east slope where the above described types are found. The west slope of the Sierras in the region covered by the Tahoe National Forest is the richest gold producing locality in the state. The mining boom which followed the discovery of gold in 1849 was followed by a period of settlement which brought with it the exploitation of a large amount of the virgin yellow pine, sugar pine, douglas fir, white fir, and incense cedar, which originally covered a large part of this country.

Reproduction, chiefly of yellow pine, came in quickly on the cut-over areas and growth is extremely rapid on account of favorable soil and moisture conditions. Consequently we have a combination of virgin stands of high yield with many scattered second growth even-aged stands from thirty-five to fifty years old which compare favorably in density, quality, and rate of growth with the even-aged douglas fir stands on the western foothills of the Cascade Mountains in Washington and Oregon.

The party last season consisted of four field assistants, a packer-cook and a forest assistant. A second forest assistant and a ranger, who were engaged in timber sale work and silvical studies, joined the party at intervals. The method used was the strip system which was followed throughout the district. A strip one chain wide in dense timber and two chains wide in more open stands was run through the centre of each " forty." This gives an estimate based upon five or ten per cent of the area. In most cases distances could be obtained with sufficient accuracy by pacing but the chain was frequently used in locating corners and running difficult lines. The Forest Service standard staff compass was employed. The compassman ran out the line for each strip, tallied the distance covered, took necessary field notes, mapped topography and types on a scale of four inches to the mile, and noted elevations, which he obtained from aneroid readings. The estimator recorded the D B H and the number of sixteen foot logs of all the trees on the strip, and took silvical notes.

Frequent checks of diameter and height estimates were made by means of the hypsometer and diameter tape. For each forty the per cent of cull for defects in each species was noted and a correction factor was applied when, in the estimator's judgment, the strip did not represent average conditions on the forty.

All trees twelve inches and over in diameter were included in the estimate of the total stand. Trees six to twelve inches D B H were tallied by diameter classes and recorded by number of each species. Trees between six inches D B H and five feet in height were described as saplings; trees below five feet in height were classed as seedlings. These two classes were estimated by the total number per acre and the percentage of each species. The silvical data noted for each forty covered the following points: rock, soil, ground cover, underbrush, condition of timber (in detail by species), average age, factors aiding or hindering logging, adaptability of land.

When a section was completed, a brief forest description was written, summarizing the points on the forty sheets, and including a description of the timber by species, according to size, quality, and condition. No attempt was made to work up the estimates in the field, but the map work was kept up-to-date. The types were colored on the maps in accordance with a legend used throughout the district. From these section maps township maps on the scale of two inches to the mile were later made in the office.

The work was entirely in surveyed land and in most cases little difficulty was experienced in finding the old Land Office corners, most of which were set from thirty-five to fifty years ago. Copies of the original field notes were of great value in retracing the work of the old surveyors. As a rule only two miles of exterior lines were run and blazed for each section estimated. These were sufficient to establish points to which the strips could be tied. All forest boundary lines within reach of camp were run out, blazed, and posted.

The total area covered was 28,500 acres; the cost per acre was $0.057. The amount estimated was 269,155,000 B. F.; the cost per M. was $0.0067.

THE ART OF PACING

E. I. Terry, B.S.F. 1907

Pacing is one of the roughest methods of measuring distance and cannot be used where a high degree of accuracy is required, but within its limitations it has a wide and extremely serviceable field of usefulness for many kinds of forest work. With a hand or staff compass the woodsman may employ it to advantage in finding section corners or other marks from known points, in tracing old lines and in cruising timber. It is the cheapest and quickest method of making forest and topographic maps, and it is the mainstay of reconnoissance work on the National Forests. The older method of running strip surveys by dragging a chain attached to the compassman's belt has been almost entirely superseded by pacing. It is therefore important, in fact often essential, for the student of forestry to become proficient in the art of pacing. To do this he must have much practice, but there are certain underlying principles which one must understand and apply in order to do consistently accurate work.

For one thing, it is much better and easier to count every *double pace*, — that is, every time the same foot is put forward — than it is to count " with both feet " as most novices and even some experienced pacers do. Our word pace is derived from the Latin *passus*, and that itself meant a double pace. A thousand *passus* made the Roman mile, which was approximately 5000 feet, so the average double pace of the Roman soldier was about five feet. In counting paces with a tally-register — to which I will refer later — it is much easier to record double than single paces.

Again, most beginners try to take an artificial step, such as a three-foot stride. That is exactly the wrong way to pace. The right way is to determine the length of one's natural stride by pacing several times over a measured line which should be at least a quarter of a mile in length. Pacing between section-corners where the lines are clearly blazed and the corners are known to be correctly set, affords the best practice. For example, if a man finds that he takes, on the average, 1000 double paces to the mile, the length of his double pace is 5.28 feet. Then, to find the distance in feet between any two points which he has paced off, he will multiply the number of paces by that figure. But in calculating the area of large tracts in acres, the foot is a very inconvenient unit of measurement. We should here use the Gunter's chain, as does the Government Land Office in all its surveys. Ten square chains equaling one acre, it is a very simple matter, if the dimensions of a tract have been obtained in chains, to find the acreage. The woodsman therefore should determine his average stride in terms of chains, or the number of paces that he takes to one chain.

But, having determined the length of his stride on level ground, there are a number of modifying factors which one must consider in standardizing his pace. The length of one's stride varies according to the rate at which he travels, — it is longer the more rapidly he walks. One should endeavor to pace at a uniform rate, which rate should not be too fast; he should take a pace in the morning which he can maintain throughout the day. Ordinarily, on comparatively level ground, the rate should not exceed that of three miles an hour.

The slope of the ground is an important factor. A man's natural stride is longer on level ground than in either going up or down hill, and somewhat shorter in ascending than in descending the same slope. In Professor Cary's "Manual for Northern Woodsmen," the results of one extensive test are tabulated, which shows that the length of step ascending a 30° slope is almost exactly half of what it is on the level. A man should, therefore, determine his length of pace on slopes of different degrees as well as on level ground. In practice, it is sufficiently accurate if one determines his pace for what may be roughly classed as gentle, medium, and steep slopes. In my own case, for example, I take on level ground 960 double paces to the mile, or twelve to a chain. On slopes averaging 10° to 15°, I take fifteen paces to a chain, on slopes of 20° to 25°, eighteen paces, and on slopes of 30° or more, twenty-one to twenty-five paces. In hilly country, it is easy to find slopes varying from gentle to steep (or lines of different grade may be laid out on one steep slope), which will hold a *uniform* grade for a horizontal distance of at least a few chains. On such slopes one should measure accurately as long a line as he can lay off up to, say, five chains, and then by pacing back and forth a number of times, determine his average number of paces to the chain, ascending and descending, for the three classes of slope. He can then compare these results with his length of pace on the level, and thus find out how many paces to allow — or how often to "drop" a pace — in going up or down slopes of different gradient. Otherwise, his allowance for slope will be mere guesswork.

One's physical condition also affects the length of his pace. His stride will be shorter when he is tired than when fresh unless he consciously forces himself to greater exertion. In changing one's field of work from a certain region to another of decidedly different topography — as in going from a level to a mountainous country — he will generally find that he needs considerable practice in order to adjust his pace to the new conditions.

For counting paces or keeping track of the distance travelled, pedometers are, especially in mountainous country, worthless. The most satisfactory instrument is the hand tally-register, or "clicker," which registers up to 1000 and may be set back to zero at any time. Each double pace can be easily registered with this machine. In allowing for slope the extra paces should be dropped at regular intervals, for instance, — if a man takes twelve paces to the chain on level ground and is going up a slope that requires fifteen, he drops, or fails to register, every fourth pace; for a slope requiring eighteen paces to the chain, every third pace; and for twenty-four paces, every other pace. At the end of a mile, his register will always show the number of paces that he takes to cover that distance on level ground.

Another method of recording the distance travelled, which has some obvious advantages in map-making and reconnoissance work, is to register each chain. Using this method, one who takes twelve double paces on the level will count his paces mentally and click the register at the end of each twelfth pace; when he comes to a gentle slope, he will count fourteen or fifteen paces before registering, and on steeper slopes eighteen, twenty, or twenty-four paces, as the grade requires. In this way he can readily make allowance for slopes of different gradient and can quickly and easily locate his position on the map. At the end of one mile his register will always show the number eighty.

In covering large acres by means of compass and pacing, the work should of course be tied in at frequent intervals to points that have been accurately located. Reconnoissance crews, when working in unsectionized country, have found it sufficient to run transit or compass lines two miles apart, the reconnoissance men pacing back and forth between these lines and generally running their lines one-quarter of a mile apart. This makes only eighteen miles of surveyed line to a township.

Pacing as a means of measuring distance has doubtless never been developed to its full capacity, but it has probably been most fully developed in the reconnoissance work on the National Forests. In Johnson's "Surveying," the statement is made that when a man's pace has been standardized and he walks at a constant rate, distances can be determined "to within two per cent of the truth." The author probably referred to open and comparatively level ground, yet I believe that in much of the reconnoissance work in the Rocky Mountain forests the error has not exceeded that. Day after day I have seen some of the best pacers in our reconnoissance crews run the two miles between surveyed lines, offset a quarter-mile and run back, and as a rule check up within six or eight rods, and they would often come much closer. So important is the method in much of our present-day work that I think it is not an overstatement to say that a man cannot be a good American forester unless he is a good pacer — he certainly will not make a good reconnoissance man.

SOME ORIGINAL DATA ON WATERFLOW AND FORESTS

H. O. Cook, M.F. 1907

Some time ago, I came into the possession of some data that I hoped would add perhaps to our knowledge of the effect of forests on waterflow, from the statistical standpoint. Data of this description are so scarce in this country that I considered that any which promised results should be worked up, no matter how incomplete it might be.

The city of Fall River takes its water from a large pond, some three miles in length and a mile wide, called North Watuppa Pond. Owing to certain legal restrictions, which it is not necessary here to describe, they are obliged to let a certain percentage of the waterflow through a weir into South Watuppa Pond, a body of water which is used by the mill interests of the city as a reservoir. In 1899 the Water Board of the City commenced an extensive investigation, the purpose of which was to determine the total amount of water which each year is delivered to the mills, the amount used by the city through its mains, the amount lost by evaporation, the amount supplied to the pond through direct precipitation, and the amount supplied to the pond by the streams emptying into it. This investigation covered three years and the results were very interesting. They published the data and conclusions in 1902 as a *Report of the Reservoir Commission*, by Arthur T. Safford, consulting engineer. To obtain part of their necessary data they built weirs at the mouths of the various brooks entering Watuppa Pond, and at these weirs took daily measurements of the waterflow for three years, 1899, 1900, 1901. It is these weir measurements that furnish the waterflow data.

In the spring of 1908, the Massachusetts State Forester's office made a forest working plan for the 5,000 acres of land included in the watershed of North Watuppa Pond, and as a necessary part of the working plan we made a forest map of the watershed. From this forest map we derive the necessary data for the forest area and types of forest land on the eight brook watersheds. Although six years elapsed between the collection of the two classes of data, due allowance has been made on the forest areas for woodland cut in the intervening time.

In the large table the daily waterflow for three years has been combined and averaged for each month. Then each of these figures has been reduced or measured by a factor which would make the watershed of each brook equal to one square mile. In the second column we have expressed in percentage the departure of the monthly flow from the average flow of the twelve months. The departures from the mean give a better means of comparison than the figures of actual flow. We include also a table of rainfall for the same three years.

Description of Watersheds

South Nat Brook

Watershed, 105 acres. Woodland, 25%.

Although only one-quarter of the watershed of this brook is forested it is in this section that it has its source. The forest is of large hardwoods growing on a moist and almost swampy flat. The entire watershed is very level and the brook flows for about four-fifths of its course through level meadows and mowings before emptying into the pond. The soil is deep and loamy.

Terry Brook

Watershed, 140 acres. Woodland, 65%.

This brook flows through a level watershed its course being bordered on both sides by maple swamp. Of the forest land about one-third is maple swamp. The soil is shallow and rocky and many out-cropping ledges testify to the nearness of the underlying rock.

Queen Gutter Brook

Area, 402 acres. Woodland, 95%.

This watershed is long and narrow and has a well defined slope. The soil is gravelly and deep. The bed of the brook is swampy and wooded with red maple. The greater part of the wooded land, however, consists of sprout oak and some pine.

North Nat Brook

Watershed, 135 acres. Woodland, 18%.

This brook has its source on a small shallow pond and flows for its entire course through open meadow land. The forest land of sprout oak is in a far corner of the watershed where it can have but little influence on the flow of the brook. The topography is flat and the soil deep.

Run Brook

Watershed. 125 acres. Forest area, 100%.

This watershed has a well defined slope and a rocky gravelly soil. The forest is sprout hardwoods much of which has been cut off. The course of the brook is short and it takes its rise in outcropping springs situated not far above the weir.

Ralph Brook

Watershed, 215 acres. Forest area, 40%.

The watershed of this brook is generally flat with a deep loamy soil. The brook has most of its course through open land. It has one source in a maple swamp and another in a small pond hole in the midst of some large hardwoods. The conditions of the watershed resemble greatly those of South Nat Brook, but the flow is much more regular.

Blossom Brook

Watershed, 1,372 acres. Woodland, 85%.

Not only is this watershed thoroughly forested but nearly one-half of it is swamp, so that conditions would seem ideal for a regular flow of the stream; but Mr. Stafford suspects that much of the precipitation on this watershed passes into the pond underground and that the weir measurements only represent a part of the actual run-off, especially in dry weather.

Conclusions

Although the flow of all these brooks is so extremely irregular as to allow little choice, I have classified those which seem to be somewhat more regular than the others as follows:—

Irregular are South Nat, Terry, and North Nat, and Queen Gutter, and regular flowing are, Run, Ralph, and Blossom. Of the irregular brooks North and South Nat brooks have very little forest on their watersheds, whereas Terry and Queen Gutter are well forested. Queen Gutter has a well defined slope on its watershed, whereas the watersheds of the other brooks are quite flat.

In case of the regular flowing brooks the watersheds of Run and Blossom brooks, are entirely forested whereas Ralph Brook is only one-half forested. Blossom and Run brooks have a considerable area of swamp on which to depend for storage but Run brook has no swamp land in its watershed.

The reader can easily see from the nature of the above facts that it would be exceedingly hazardous to venture to draw any conclusions from them. A different story would probably be the result of these measurements had they been taken in a mountainous country with a rocky slope, but in a country of comparatively slight slopes and a deep gravelly soil the effect of a forest cover would not seem to be very large in the run-off of streams.

It is interesting to note how much more consistent, from month to month, is the flow of the streams than the precipitation. An excess of seventeen per cent in the rainfall of September does not seem to have had much effect on the run-off of that month or the next.

AVERAGE FLOW PER DAY AND PER SQUARE MILE OF WATERSHED OF THE BROOKS ON THE NORTH WATUPPA WATERSHED SHOWING MONTHLY DEPARTURES FROM MEAN MONTHLY FLOW MEASUREMENTS OF THREE YEARS

Months	All Brooks	Depart.	South Nat	Depart.	Terry	Depart.	Queen Cutter		North Nat		Run		Blossom		Ralph		Rainfall	
	1000 gals.	Per cent	1000 gals.	Per cent		Per cent		Per cent		Per cent		Per cent		Per cent		Per cent	Inches	Per cent
January	1,349	+33	2,652	+174	2,216	+60	1,017	+25	935	+82	861	+25	1,413	+25	872	+24	4.12	+11
February	1,555	+49	1,524	+57	2,247	+62	1,181	+44	625	+21	813	+19	1,614	+43	1,055	+50	3.30	−11
March	3,057	+201	2,925	+202	4,399	+217	2,691	+231	1,262	+145	1,758	+156	3,292	+192	1,803	+155	6.00	+61
April	2,256	+122	1,716	+77	3,012	+118	2,077	+155	1,221	+137	1,852	+170	2,448	+117	1,767	+150	4.22	+13
May	1,968	+94	1,642	+70	2,274	+64	1,741	+114	828	+61	1,461	+112	2,307	+105	1,300	+84	5.06	+36
June	332	−67	184	−81	644	−54	413	−50	188	−63	482	−30	649	−42	340	−51	2.40	−36
July	160	−84	20	−98	47	−97	61	−92	61	−88	83	−88	236	−80	80	−89	2.96	−20
August	54	−95	1	−100	0	−100	1	−100	6	−98	26	−96	82	−93	14	−98	2.04	−45
September	90	−91	88	−90	14	−99	20	−96	53	−90	46	−93	135	−90	59	−91	4.36	+17
October	185	−82	200	−79	60	−95	15	−97	171	−66	146	−80	264	−76	178	−74	3.33	−11
November	280	−72	201	−79	332	−76	55	−93	155	−70	225	−67	346	−70	221	−68	2.77	−23
December	750	−26	1,194	+23	1,227	−11	517	−36	652	+27	190	−28	744	−34	787	+12	4.12	+10
Mean	1,015		968		1,386		813		514		687		1,126		705		3.72	