Obtaining Accuracy in the Application of Materials to Turf

By Fred V. Grau

The application to turf of materials for various purposes has become an increasingly important phase of golf course maintenance more particularly since the recent development of highly concentrated fertilizers, insecticides, and fungicides. This development has come as a result of the golfers' demands for better playing conditions, with the accompanying need for finer turf, which must be kept free of pests and diseases. The research which has been responsible for determining the value, the practicability, and the limitations of the many materials which are used so widely on golf courses has, in the aggregate, effected enormous savings for the clubs of the country. In particular, freight charges and handling costs have been reduced by the use of more concentrated materials.

In spite of these accrued benefits it must be acknowledged that, even though more of the greenkeeper's problems have been solved for him, his position has not been simplified. He has had to face an entirely new problem—that of properly applying these concentrated materials so that he will not injure the fine turf entrusted to his care. Unfamiliarity with the nature of many of the materials often has been reflected in their careless use, which has too often ended in disastrous results both to the turf and to the greenkeeper's position. Before any material is definitely recommended by the Green Section for golf course purposes many tests are made. In these tests a definite amount of material is applied to an exact area, and the beneficial results of some treatments depend largely upon the accuracy with which the materials are applied. It is the purpose of this discussion to point out that the application of materials on golf courses should, for the best results, be made at approximately the same rates as employed in these tests, and to suggest some simple aids which may be of benefit in organizing and employing a definite program from which guesswork has been eliminated.

The harmful and often disastrous effects resulting from carelessness and misuse of highly concentrated materials are well known. The Bulletin has often called attention to them and has suggested ways and means of simplifying the attendant problems. Methods of applying chemicals to putting green turf are discussed in the Bulletin for November, 1931. It is not an uncommon sight to visit a course and to view the disastrous results of guesswork in the application of powerful materials. The uniform application of such a small amount of corrosive sublimate as 1½ ounces to 1,000 square feet, for example, involves dilution with a suitable inert carrier. It is applied as a spray in water or applied dry with soil. The results from either method, when the chemical is properly applied, have been generally satisfactory. When applied in excess, through carelessness or insufficient knowledge, the results have usually been highly unsatisfactory. Deep, brown scars or burns appear, which heal but slowly, and, in many cases, the failure of the application causes the chemical to be branded as unsafe and too dangerous to be used freely.

Similar instances may be recalled in connection with the use of certain fertilizers. A given amount of fertilizer may be applied to each putting green on the course without regard to differences in the size of the respective greens. By this method a green of 4,000 square

feet would receive twice the amount of fertilizer that would be applied to a green of 8,000 square feet. By considering this, the differences arising from such indiscriminate practices are easily explained even though the reasons may be obscure to the uninformed.

Due to certain variations in the soil and in the environmental conditions surrounding individual putting greens two greens of exactly the same size may require quite different treatments. Nevertheless, the area of each should be known, so that the proper amounts of materials may be applied, whatever the rate. Many greenkeepers have guarded against the disastrous results of guesswork in applying concentrated materials by employing a simple method. The exact amount of a given material is measured accurately for a given area, placed in a suitable container, and labeled accordingly to correspond with the area for which it is intended. Then, with simple instructions for mixing and applying it, any laborer can, even in the absence of the greenkeeper, apply the material with the assurance that the results will be as satisfactory as those obtained by a more experienced operator.

The Bulletin and other publications have repeatedly pointed out that the extremely unnatural conditions existing on putting greens increase the difficulties of maintaining putting-turf grasses. Fine turf often suffers needlessly as the result of inaccuracy in the practices of ministering to its requirements, much as a sick person might suffer should the physician administer an overdose of a poison which, in the proper amount, would act as a stimulant and an aid to rapid recovery.

The factors involved in obtaining accuracy in the application of materials seem to fall into three main heads, which will be presented in this article in the following order: (1) accurate determination of the size of the area to be treated; (2) accurate determination of the amount of material to be applied to the area; (3) even distribution of the material.

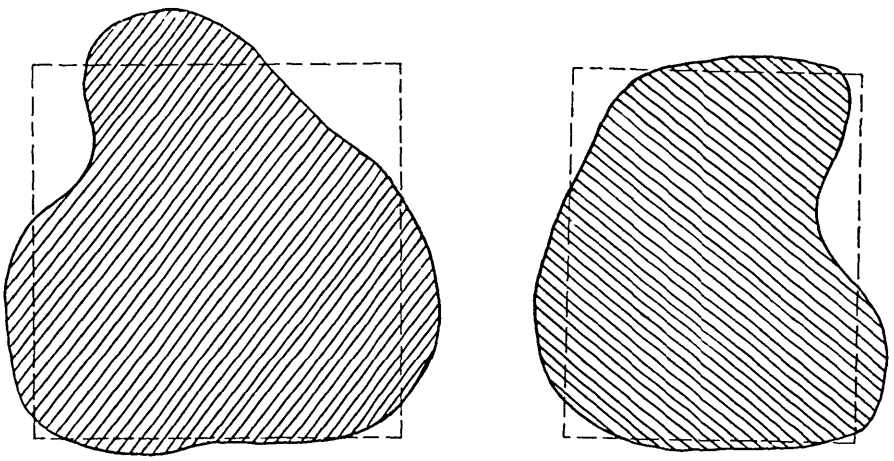
Measuring the Area

A recommended rate of application means that a certain amount of the material should be applied to a definite area for certain results; any divergence from this rate can not be expected, except under unusual circumstances, to give the desired results. Modern appliances permit of the accurate measurement of materials of all kinds. Clearly then, the misuse of certain materials often is occasioned neither by their particular effects nor by the lack of accurate measuring devices, but by lack of knowledge of the exact size of the area to which they are to be applied.

Irregular outlines appear to present almost insurmountable difficulties when the exact extent of the area is to be determined. This is especially true of putting greens, which often are irregular in outline. That little difficulty need be experienced in calculating with reasonable exactness the areas of irregularly shaped putting greens has been demonstrated by comparing the results obtained by the use of the simple guide shown in the accompanying drawings with a number of mathematical calculations.

The method illustrated in the drawings for determining the areas of putting greens is simple and requires no equipment. The squaring of the outline is done entirely by approximation and by judgment,

after which the length and width may be measured with a tape or by pacing. The multiplication of the length by the width, in square and rectangular figures, gives the area in square feet or square yards as the case may be. Some clubs take the measurement of the putting greens from the architect's plans which they may have in their possession. The original plans or blue prints, however, are not always strictly followed in building the course, and the actual putting areas may vary as much as 1,000 feet or more from the area shown on the plans. The greenkeeper should, therefore, measure the putting greens regardless of plans.



The two putting greens here outlined appear at first sight to present considerable difficulty in determining their exact areas. The dotted lines show how, by taking the average length and width in feet, a reasonably accurate determination can be made. The same amount of putting green area should be left outside of the squared lines as there is blank area inside of them

Table 1 is presented to aid in determining the areas of circular putting greens. The area of a circle may be found by multiplying the square of the radius or of half of the diameter by 3.1416. In order to use the table it is necessary to know only the diameter of the green in feet. The diameter of a circular putting green is measured from edge to edge of the putting turf, the line passing through the center. The center of the green can be judged closely enough to measure the diameter. This table gives areas of greens down to 25 feet in diameter since temporary putting areas of this size are sometimes found.

TABLE 1.—AREAS OF CIRCULAR PUTTING GREENS OF VARIOUS DIAMETERS

Diameter in feet.....	25	30	35	40	45	50	55	60
Area in square feet....	490	706	962	1,256	1,590	1,963	2,375	2,827
Diameter in feet.....	65	70	75	80	85	90	95	100
Area in square feet....	3,318	3,848	4,417	5,026	5,674	6,361	7,088	7,854

Teeing areas are usually regular in outline and rectangular in shape. In determining their size they ordinarily present no difficulties. It is important, however, that they too be measured, since they constitute an important part of the playing area of the golf course and require applications of fertilizers or other materials.

The areas of fairways perhaps are determined more by guesswork than are areas of any other part of the course. It is essential that they too be measured with reasonable accuracy. By having the correct size it becomes a much simpler matter to figure how much material will be needed during the course of a season. It is often the lack of accurate measurements or inability to make the simple calculations necessary to determine the area to be fertilized, that accounts for differences in fairway turf between one part of the course and another. A greenkeeper may try to apply so many pounds of fertilizer to an acre, and when about half of the course has been covered he finds he has only about one-quarter of his fertilizer left. As there has been a 50 per cent mistake either in his calculations of fairway area or in the amount of fertilizer applied to an acre, it is necessary to cut the rate of application in half for the remainder of the course in order to make the fertilizer last to the finish of the job.

This big difference in the amount of plant food applied to these different areas can easily account for differences in turf. There are some greenkeepers who do not know how to calculate the number of pounds their fertilizer spreader is distributing to the acre; consequently if the acreage of various fairways is not definitely known a great proportion of the course has to be fertilized before these men are able to make a guess with any degree of accuracy as to how the fertilizer is lasting. It is for this reason that they frequently play safe and apply not nearly enough. The committee may, on the greenkeeper's request, buy enough fertilizer to cover say 50 acres of fairways at 800 pounds to the acre. The greenkeeper is afraid he may run short, and guesses the rate of distribution a little low, and only 600 pounds to the acre goes on the course. This miscalculation sometimes accounts for the fact that a greenkeeper has 5 or 6 tons of fertilizer still in his shed after he has covered the entire course.

Fairway and rough areas are measured in acres, on which basis rates of application for these areas are given. Since fairways are usually measured in yards, and since a full stride measures approximately a yard, the figures in tables 2, 3, and 4 are given on that basis.

The width of a fairway is the average of its widths at several places. The length of pace of men varies, but usually the variation is so little that the paces of most men may be considered as a yard in length for the purpose of measuring such comparatively short distances as fairway widths. Pacing the length of fairways, however, will hardly give sufficiently accurate results on long holes, unless the one doing the pacing makes some preliminary tests. When measuring the length of fairways 100 or more yards long the greenkeeper should check the length of his pace before pacing off these longer distances. The length of his stride may be sufficiently greater or less than an exact yard to make a considerable error in a long fairway. In accurate pacing, the pacer first steps out a measured distance, say 100 yards, on level ground, to learn how many paces he takes to the hundred yards. As a man takes longer strides going downgrade than climbing, distances on grades should be paced both down and upgrade and the average of the two counts taken. Some greenkeepers will no doubt find it more convenient to use a tape, rather than to pace the length of their fairways.

If the yardage of holes given on the score card has been accurately determined, these distances may be used to determine fairway areas provided the average widths of the various fairways are known. In using the score card it must be remembered that the yardage shown is from center of tee to center of green. The relatively short distance from the front of the green to the center seldom amounts to more than 15 yards, and may be deducted when calculating fairways that end at the front of the putting green. On most golf holes, however, the fairway should extend around the sides and rear of the putting green; and if such is the case no allowance need be made, since this narrow strip of fairway around the green makes up for the area taken up by the putting green. The area extending from 100 to 150 yards from the tee is usually maintained as rough and is not therefore calculated as fairway area, and this distance, whatever it may be, should be subtracted from the yardage shown on the score card.

TABLE 2.—AREAS, IN ACRES, OF FAIRWAYS OF VARIOUS WIDTHS AND LENGTHS

Fairway width	Fairway length (yards)							
	25	50	75	100	200	300	400	500
Yards	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
25	.14	.26	.39	.51	1.03	1.55	2.07	2.58
30	.15	.31	.46	.62	1.24	1.86	2.48	3.09
35	.18	.36	.54	.72	1.44	2.17	2.89	3.61
40	.21	.41	.62	.82	1.65	2.48	3.30	4.13
45	.23	.47	.69	.93	1.86	2.79	3.72	4.64
50	.27	.51	.77	1.03	2.07	3.10	4.13	5.16
55	.29	.57	.85	1.13	2.27	3.41	4.54	5.67
60	.31	.62	.93	1.23	2.48	3.72	4.95	6.19
65	.35	.67	1.01	1.33	2.68	4.00	5.37	6.71
70	.36	.73	1.08	1.44	2.90	4.34	5.78	7.22
75	.40	.78	1.16	1.54	3.10	4.65	6.19	7.74
80	.42	.84	1.24	1.64	3.31	4.96	6.60	8.25
85	.45	.88	1.31	1.75	3.51	5.27	7.02	8.67
90	.47	.95	1.40	1.85	3.72	5.58	7.43	9.18
95	.51	1.01	1.48	1.95	3.92	5.90	7.85	9.70
100	.52	1.06	1.54	2.06	4.13	6.21	8.26	10.21

Very often only approaches to putting greens and certain areas called landing areas, upon which a great majority of the shots are played, are fertilized. This procedure is often followed in cases where the club has to economize. Instead of applying fertilizers over all the fairways at such low rates that any improvement in turf would be so slight as to pass unnoticed, the fairway area to be fertilized could be reduced by one-half or even two-thirds. Only poor areas needing improvement or areas of fairway receiving most play and hence needing most plant food to force the grass to fill in the divot holes and form a heavy turf need be fertilized by this plan. In such cases the greenkeeper will have to mark these selected areas and then measure their extent. By determining the size of these approaches and landing areas the greenkeeper will know how to best make use of the comparatively small amount of fertilizer at his command. There are 4,840 square yards in an acre. Therefore, if a fairway is 60 yards wide there is an acre for about every 80 yards of its length.

Table 2 permits of rapid determination of fairway areas. For example, consider a fairway 325 yards long, not counting the rough in front of the tee. The width of the fairway is paced at different intervals and is found to average 60 yards. From the table, the acreage would be the sum of the figures in the columns headed 300 and 25, and opposite the 60-yard fairway width, or 4.03 acres. If it were figured without the use of the table, 325 would be multiplied by 60 and the product divided by 4,840.

Determining the Amount to Apply

Table 3 is included for calculation of amounts of materials needed for different-sized areas. For example, if it is desired to apply a material at the rate of 4 ounces to 1,000 square feet, to an area of 5,500 square feet, the amount needed for the area is found in the

TABLE 3.—UNITS OF MATERIALS NEEDED FOR AREAS OF VARIOUS SIZES IN APPLICATIONS AT GIVEN RATES FOR 1,000 SQUARE FEET

Size of area in square feet	Rate of application in given units (ounces, pounds, gallons, cubic yards) to 1,000 square feet							
	½	1	2	3	4	5	10	15
	Units needed	Units needed	Units needed	Units needed	Units needed	Units needed	Units needed	Units needed
500	.25	.50	1.00	1.50	2.00	2.50	5.00	7.50
1,000	.50	1.00	2.00	3.00	4.00	5.00	10.00	15.00
1,500	.75	1.50	3.00	4.50	6.00	7.50	15.00	22.50
2,000	1.00	2.00	4.00	6.00	8.00	10.00	20.00	30.00
2,500	1.25	2.50	5.00	7.50	10.00	12.50	25.00	37.50
3,000	1.50	3.00	6.00	9.00	12.00	15.00	30.00	45.00
3,500	1.75	3.50	7.00	10.50	14.00	17.50	35.00	52.50
4,000	2.00	4.00	8.00	12.00	16.00	20.00	40.00	60.00
4,500	2.25	4.50	9.00	13.50	18.00	22.50	45.00	67.50
5,000	2.50	5.00	10.00	15.00	20.00	25.00	50.00	75.00
5,500	2.75	5.50	11.00	16.50	22.00	27.50	55.00	82.50
6,000	3.00	6.00	12.00	18.00	24.00	30.00	60.00	90.00
6,500	3.25	6.50	13.00	19.50	26.00	32.50	65.00	97.50
7,000	3.50	7.00	14.00	21.00	28.00	35.00	70.00	105.00
7,500	3.75	7.50	15.00	22.50	30.00	37.50	75.00	112.50
8,000	4.00	8.00	16.00	24.00	32.00	40.00	80.00	120.00
8,500	4.25	8.50	17.00	25.50	34.00	42.50	85.00	127.50
9,000	4.50	9.00	18.00	27.00	36.00	45.00	90.00	135.00
9,500	4.75	9.50	19.00	28.50	38.00	47.50	95.00	142.50
10,000	5.00	10.00	20.00	30.00	40.00	50.00	100.00	150.00

5,500 line under the column headed 4; namely, 22 ounces. If on the same area one wishes to apply a material at the rate of 12 ounces he can readily determine the amount to apply by adding the numbers opposite 5,500 under the columns headed 10 and 2, which is found to be 55 plus 11, or 66 ounces. By thus combining the figures in the columns one can get by simple addition the quantity needed at any of the ordinary rates of applications. The amounts needed for other areas not shown can be readily obtained by taking the proportionate amount between the two nearest figures in the table; for example, 5,250 is half way between 5,000 and 5,500, and thus for a rate of 4 ounces it would require between 20 and 22 ounces, as shown in the table, or 21 ounces. The rates shown in the table may represent ounces, pounds, gallons, cubic yards, or any other unit of measurement.

The use of a ready-reference chart such as outlined below is suggested as an aid in organizing the treatments of putting greens with a view to obtaining accuracy in applying materials to the turf. The numbers of the holes are arranged vertically in the column at the left. In the next column are to be entered the areas of the respective putting greens. Above the word "amount" at the head of the several columns, in the space marked "rates," are to be entered the rates of application in common use. For example, the first column may be used for the rate "1½," representative of a rate of application of corrosive sublimate; the second column may be headed "3," and so on; or the series of rates shown in table 3 may be entered, if applicable to the needs of the course. In the blank spaces for the respective greens in the columns headed "amount," are to be entered the amounts of materials needed for the areas involved as determined by the figures in table 3. The value of such a ready-reference chart as this will be proportional to the care with which it is prepared and the extent to which it is used.

READY-REFERENCE CHART SHOWING AMOUNTS OF MATERIALS NEEDED FOR VARIOUS RATES OF APPLICATION FOR PUTTING GREENS

Putting Greens								
		Rates to 1,000 square feet						
Number	Area	Am't	Am't	Am't	Am't	Am't	Am't	Am't
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
Practice								
Total								

It is suggested that a copy of this chart be made on large, heavy paper and that similar copies be made for tees and fairways. For the fairways chart the rates can be put down in acres instead of the unit of 1,000 square feet used in the charts for the putting greens and

tees. The areas may be determined by using tables 1 and 2 for insertions in the chart. Tables 3 and 4 can then be used as guides for filling in the rest of the columns. More columns for amounts than are shown in the blank chart will no doubt be found useful in the large copies.

On courses where mixing equipment is used and where corrosive-sublimate treatments, for example, are applied dry mixed with topsoil, the following procedure suggests itself. It is desired, for example, to apply 1½ ounces of corrosive sublimate to 1,000 square feet of putting surface. The amount for each putting green at that rate has been properly marked on the chart. The total amount required is the total of the column headed "1½ ounces," which is, for example, 8½ pounds. The total area of putting surface is found at the bottom of the column headed "area," under "putting greens," which, we will say, is 90,000 square feet. In the Bulletin for November, 1931, it was suggested that fungicides may be mixed with topsoil and broadcast at the rate of an 8-quart bucketful of topsoil to 1,000 square feet. It is thus apparent that when 90 buckets of topsoil are thoroughly mixed with 8½ pounds of corrosive sublimate and broadcast at the suggested rate, the proper amount of fungicide will be applied.

Seeding rates may likewise be entered on the chart. Many other uses for it will suggest themselves with continued use. Its principal benefit will be to eliminate the necessity for memorizing or calculating the amounts required each time an application of material is needed.

Applying the Material for Even Distribution

There are two commonly-used methods of adjusting a distributor to throw the desired amount of material. One is to run it over a measured area and determine by difference how much material was used, after which an adjustment is made and the procedure repeated until the proper set is obtained. The other makes use of the knowledge of the area covered by a machine of certain width in traveling a given distance. By putting a certain amount of fertilizer in the hopper and by pacing the progress of the machine the greenkeeper can stop the machine at a predetermined distance, quickly ascertain the rate at which the material is being applied, and make the necessary readjustments. The proper adjustments can usually be made at the start of the job before an acre has been covered. Of the two methods, the latter is perhaps the simpler and more satisfactory since, with the assistance of tables here presented, only the width of the spread need be known.

The spreader should have on it some arrangement whereby the flow of the material may be stopped at once when the machine is stopped. Many instances have been observed where piles of the fertilizer have run out where the machine was stopped. This is not only wasteful of material but the resulting uneveness of the turf is unsightly. An additional precaution to avoid uneveness is to draw the fertilizer distributor in a circular motion around the fairway, as in mowing. This avoids any necessity for stopping the motion of the machine except for loading, and aids in obtaining uniformity of distribution. Most greenkeepers have a man ride the distributor or follow it over the entire job as an extra precaution. By so doing

any irregularity in flow, stoppage of the feed, or breaks in the mechanism may be immediately detected and corrected. This procedure allows the operator of the tractor to focus his attention upon properly guiding the outfit so that no part of the course is missed or doubled.

The material should be applied on a calm day. Therefore with machines such as lime spreaders only the width of the spreader hopper need be measured. In other distributors, such as the type that throws the fertilizer out by means of fans, the extent of the spread or coverage of the bulk of the fertilizer must be measured. If a machine spreads fertilizer at a width of 10 feet, it must move 1,452 yards to cover an acre. If it is to spread 800 pounds an acre, it must use this much in that distance. Therefore if it uses 1/10 of that much fertilizer, or 80 pounds in 1/10 of the distance (145 yards), the distributor is set correctly. However, 80 pounds is probably too small a quantity to put in the hopper for most machines to work perfectly.

TABLE 4.—YARDAGE TO BE TRAVELED BY DISTRIBUTING MACHINES OF VARIOUS HOPPER WIDTHS TO DISCHARGE 200 POUNDS OF MATERIAL AT VARIOUS RATES TO THE ACRE

Width of hopper in feet	Rates in pounds to the acre									
	100	200	300	400	500	600	700	800	900	1,000
	Yards	Yards	Yards	Yards	Yards	Yards	Yards	Yards	Yards	Yards
5	5,808	2,904	1,916	1,452	1,161	950	830	726	644	580
6	4,840	2,420	1,597	1,210	968	798	692	605	537	484
7	4,148	2,074	1,368	1,037	829	684	593	518	460	414
8	3,630	1,815	1,197	907	726	600	519	453	403	363
9	3,226	1,613	1,064	806	645	532	461	403	358	322
10	2,904	1,452	958	726	580	479	415	363	322	290
11	2,640	1,320	871	660	528	435	377	330	293	264
12	2,420	1,210	800	605	484	400	346	302	268	242
13	2,234	1,117	737	558	446	368	320	280	248	223
14	2,074	1,037	684	518	414	342	296	259	230	207
15	1,936	968	638	484	387	320	276	242	214	193
16	1,812	906	597	453	362	299	260	226	201	181

Table 4 has been prepared so that the rate at which the spreader is applying the material may be judged by using 200 pounds in the hopper for calibration. In the case just cited, of the 10-foot spreader to be set to apply 800 pounds to an acre, the machine should cover 1,452 yards to spread this amount, and if only 200 pounds is in the hopper it should cover 1/4 of the distance that 800 pounds would; therefore, the 200 pounds should be used only when the machine has gone forward 363 yards, as indicated in the table.

Table 4 thus gives the number of yards that spreaders of different widths with 200 pounds of fertilizer in the hopper must run forward to spread various amounts to an acre. This table should simplify matters for many greenkeepers. In adjusting his spreader, the greenkeeper need only weigh 200 pounds of the fertilizer to be used. Then by consulting the table he determines how far the machine should run to use the 200 pounds if it is to be applied at the desired rate. The greenkeeper need only pace along beside the machine and stop it when it has progressed the required number of yards. If the

200 pounds is used before the machine travels the required distance, the fertilizer is going on more heavily than desired, and vice versa. The necessary readjustment should be made, and the machine again loaded with 200 pounds and the trials continued until adjustment is satisfactory. If a machine is set for one fertilizer, the adjustment should be checked when another is used, because some fertilizers differ in their flowing qualities; hence adjustments should be made for each fertilizer used.

Some greenkeepers will find it convenient to make more or less permanent notes of certain figures taken from table 4, so that from year to year there need be no errors made or time lost in searching for the information needed for that particular machine. For example, if a machine distributes to a width of 10 feet, that part of the table applying to this particular width may be painted upon the distributing box, as follows:

	200 Pounds in Hopper									
Rate per acre.....	100	200	300	400	500	600	700	800	900	1,000
Yards to go.....	2,904	1,452	958	726	580	479	415	363	322	290

Missing Numbers of the Bulletin

The Green Section is frequently asked to supply a complete set of volumes of the Bulletin to libraries or individuals who have recently become interested in turf work. Unfortunately the supply of certain numbers in the early volumes has long been exhausted and it is therefore impossible to supply full sets of the Bulletin. No doubt many of the missing numbers are still in existence and serving no useful purpose. Many of our readers no doubt have kept old volumes of the Bulletin in which they may be no longer interested. We would greatly appreciate receiving any of the numbers listed below, since they can be placed where they will serve some useful purpose for reference. If any of our readers have complete volumes which they no longer need we would be glad to receive the entire volumes. If only a single number of those listed below is found we request our readers to send it to us if it is no longer needed, as it may happen to be just the number missing from some other returned set. These missing copies are needed largely for libraries of State experiment stations or other institutions where they will be useful for reference, and no doubt will be of greater service in that capacity than they would be in private files. The numbers of which the supply is exhausted are as follows:

Vol. II, 1922. All numbers.

Vol. III, 1923. January, February, March, April, May, June, November, December.

Vol. IV, 1924. January, February, March, May, June.

Vol. V, 1925. June, July, August, December.

Vol. VI, 1926. January and March.

Vol. VII, 1927. February, April, May, June, November.

Never entertain the thought that it is impossible to do anything. Patience and devotion will move a mountain, if anything will.

A theory in greenkeeping, as in science, is a valuable servant but a poor master. Conquer your theories; don't let them conquer you.