COOPERATIVE EXTENSION WORK
IN
AGRICULTURE AND HOME ECONOMICS
State of Oklahoma
D. P. TRENT, Director

Oklahoma Agricultural and Mechanical College and United States Department of Agriculture, Cooperating

Extension Service
County Agent Work
Stillwater, Oklahoma

Distributed in Furtherance of the Acts of Congress of May 8 and June 30, 1914

Simple Methods for Measurement and Calculation of Field Areas

By

J. W. CARPENTER, JR.
Extension Agricultural Engineer

and

C. V. PHAGAN
Assistant Extension Agricultural Engineer

Circular No. 306 General Series 81

Simple Methods
for
Measurement and Calculation of Field Areas

The purpose of this circular is to give and explain methods of measurement and calculation of field areas which are practical for those who have not had special engineering training. While the ability to correctly measure areas has always been important, it has become increasingly so since the inauguration of the crop control measures of the Agricultural Adjustment Administration.

UNITS OF MEASURE

The units of measure in general use in measuring field areas in the United States are the foot, the yard, the rod, and the surveyor's chain.

1 yard = 3 feet
1 rod = 16½ feet
1 chain = 66 feet, or 4 rods
1 mile = 5,280 ft. = 1,760 yards = 320 rods = 80 chains

INSTRUMENTS OF MEASURE

The accepted standard instrument of measure at present is the steel tape, which may be obtained in lengths of 50 or 100 feet. Probably the best type for this work is what is known as the steel chain tape, which comes in lengths of 50 or 100 feet and may be obtained either with or without a reel. These tapes may be obtained for approximately $6.

In a number of instances a surveyor's chain may be available. This surveyor's chain (also known as Gunter's chain) is 66 feet long and composed of 100 links, each of which is .66 of a foot long. It is especially adapted to land measure from its relation to the rod and the mile.

In case neither of these is available, a substitute may be made. One of the favorite substitutes is a wire 50 feet in length. In making any substitute measuring device extreme care should be taken in obtaining accuracy. In making the 50 foot wire, it is suggested that 50 feet be carefully measured off. Drive stakes in the ground or nails in a floor exactly 50 feet apart. Put a large size harness ring over each nail and fasten one end of the wire in one of the rings, and then in the second ring, being careful that the wire is stretched tightly between the two. A pull of 12½ pounds is about right. It has been found better to use a rather light wire, say size 14 or slightly smaller, as the pull will have a tendency to straighten out bends in the wire which might otherwise cause the measure to be shortened.

The principle objections to a 50 foot wire are the inconvenience in handling, liability of bending and kinking, and the fact that it is difficult to mark intermediate measurements on this wire. In an effort to overcome some of these objections, a chain was made, consisting of ten links. each one yard long, giving a total length of 30 feet, or ten yards. Work in the field might possibly be sped up by making this chain 20 links long, which would give a total of 20 yards, or 60 feet; however, it has been found that the longer chain is more unwieldly and gives some trouble due to bending and kinking.

In constructing this chain a small-sized wire is used. (This might even be constructed of used bailing wire, which is available in large quantities on practically every farm.) Two nails are driven in a piece of 2 x 4 timber, exactly three feet apart from outside to outside of the nails. Each wire link is then constructed by twisting the ends around these nails and wrapping around the wire. The loop on one end of the link may be completed. It is necessary to slip the loop on the other end through the loop on the adjoining link before wrapping. After the chain is completed is should be carefully checked against a standard tape. If care has been used in placing the nails around which the links are constructed so that they are exactly three feet from outside to outsideside, the tape will generally be found to be just a little short. This may usually be corrected by fastening one end and giving a good strong pull, which will take the expected stretch out of the chain. In case this is not sufficient, additional length may be given by flattening the loops at the joints slightly. In case the chain is too long it will, of course, be necessary to shorten at least one link; however, as a rule, the chain will be short rather than long, as there seems to be a tendency to shorten the link in making the wrap at each end. It has been found advantageous to add a short link three or four inches long at each end of the chain, to which either a large harness ring or a piece of rawhide may be attached for handling.

One advantage of a homemade chain constructed in this manner is the fact that distances may be measured to the nearest three feet. In order to obtain closer measurements it is only necessary to carry a two-foot folding rule, which may be used in measuring fractions of a link. Chances for error may be reduced by marking every other link on the chain to show the distance from the zero end. This may be conveniently done by twisting strands of copper wire in the joint. One strand inserted in the joint between the second and third links and twisted will show two ends, denoting the second link from the zero end; two strands twisted in the joint between the fourth and fifth links will show four ends, denoting the fourth link from the zero end; and so on. Copper wire is suggested for marking as the difference in color makes it more easily seen.

In using this device care should be taken that it does not kink in the joints, as this may materially shorten the chain.

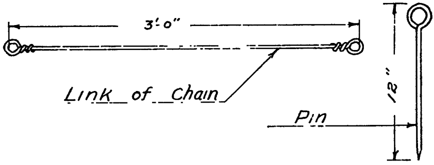

Figure 1.

An instrument which is popular on the smooth l nds and more even slopes of the wheat section is known as the "Rafter Measuring Stick" and is shown in Figure 2. This is usually constructed of 1" x 2" material. Each leg is 4 feet 1½ inches long, and the distance between the sharpened points of the legs at the bottom is exactly 4 feet 1½ inches, or one-fourth of a rod. This instrument is generally used by turning over and over as a man walks down the line. Its chief disadvantages are the difficulty in keeping the measurements properly lined up, and the possibility of missing the count.

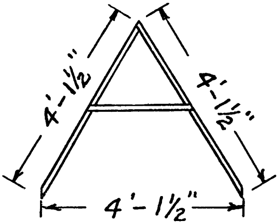

Figure 2.

MEASUREMENT OF DISTANCES

In measuring distances it is important that the tape or chain be kept definitely on the line being measured. The person carrying the front end of the chain is generally known as the front chainman, while the man carrying the rear end of the chain is known as the rear chainman. In order that measurements may be made in a straight line, the rear chainman should carefully line the front chainman on the point to which measurement is being made each time a chain length is measured. In marking the chain lengths along the line, a set of eleven pins, similar to that shown in Figure 1 is used. These should be approximately one foot long, and may be made of No. 9 or heavier wire. A strip of bright-colored cloth, usually red or white, should be tied in the loop of each pin to make it easier to find. In using these eleven pins one pin is set in the ground at the starting point. The front chainman then has ten pins. He sets a pin to mark each chain length. The rear chainman picks up this pin after the next pin in the line is set.

When ten chain lengths have been measured, the front chainman will have no pins, and the rear chainman will have ten, one pin remaining in the ground to mark the point. Notation should be made of the exchange of pins, and measurement of the distance continued. In this way a check is kept on the number of chain lengths measured. If less than ten chain lengths are measured, the number may be obtained by counting the number of pins which the rear chainman has. Frequent checks of the number of pins in possession of each of the chainmen should be made to avoid error due to loss of pins. It is extremely important that the pins be set carefully, as carelessness in setting pins causes a resulting error in the distance measured.

In the measurement of areas, all distances should be measured horizontally, that is, the tape should be held level. For practical purposes, however, the error introduced by measuring distances on the ground level may be disregarded on all slopes less than 15 per cent. Where extremely accurate results are desired, corrections may be made as shown in Table 1.

The slope of the ground is usually expressed in percentage of the amount of rise to the horizontal distance; for instance, if the ground rises 15 feet vertically in 100 feet of horizontal distance the slope is expressed as being 15%. When desired, this may be obtained by the use of a 10-foot board. One end of this is placed on the ground, and by means of a spirit level the lower end is raised until the board is level. The distance from the downhill end of the board to the ground, multiplied by ten, will give the amount of fall in 100 feet, which is the grade in per cent of the ground surface.

TABLE I

Grade	"Surface Distance"*	"Correction"**
5%	100.1 feet	0.1%
10%	100.5 feet	0.5%
15%	101.1 feet	1.1%
20%	102.0 feet	2.0%
25%	103.1 feet	3.0%
30%	104.4 feet	4.2%
40%	107.7 feet	7.2%

*"Surface Distance"—Surface distance corresponding to 100 feet horizontal distance.

**"Correction"—Percentage of surface distance to subtract in order to obtain horizontal distance.

EXAMPLE

On a 20% grade, a ground surface measurement of 1875 feet is made. Reference to the table shows a correction of 2% which should be deducted to give the correct horizontal distance. Two per cent of 1875 feet=37.5 feet. 1875 feet—37.5 feet=1837.5 feet, which is the correct horizontal distance and should be used in the computation of area.

CALCULATION OF FIELD AREAS

UNITS OF AREA

The universal unit of area in Oklahoma is the acre.

1 acre=43,560 square feet
= 4,840 square yards
= 160 square rods
= 10 square chains

In finding the number of acres in a given field, it is necessary to obtain the number of square units of measure in the area and divide this by the number of these square units in an acre; for instance, the number of acres in a field equals

$$\frac{\text{The number of square feet in a field}}{43{,}560}$$

In some instances it is more convenient to multiply than divide; for instance, instead of dividing the number of square feet in a field by 43,560, the same result may be obtained by multiplying the number of square feet in a field by .00002296.

After obtaining the area of a field in square feet, square yards, square rods, or square chains, the area in acres may be obtained as follows:

$$\text{Number of acres} = \frac{\text{square feet}}{43{,}560} \text{ or sq. ft. x .00002296}$$

$$= \frac{\text{square yards}}{4{,}840} \text{, or sq. yds. x .0002066}$$

$$= \frac{\text{square rods}}{160} \text{, or sq. rods x .00625}$$

$$= \frac{\text{square chains}}{10} \text{, or sq. chains x .1}$$

In computing areas it is advisable to use as large units of measurement as possible in order that the size of the numbers dealt with may be kept as small as possible, thus facilitating computation.

AREAS OF DIFFERENT SHAPES OF FIELDS

1. Square or Rectangle

A square and a rectangle are figures in which all the interior angles are right angles. The area is figured by multiplying the width by the length.

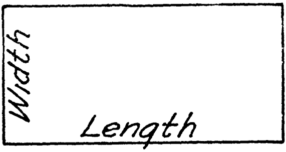

Figure 3

Example—Assume in Figure 3 a width of 460 feet and a length of 890 feet, then

Area = 460 x 890 = 409400 No. of Acres = $\frac{409400}{43560}$

= 9.4—Acres

The measurements of this field might have been measured in yards or rods. The unit used in measuring dimensions is immaterial, as long as the resulting area is divided by the proper factor for reducing it to acres.

2. Right Triangle.

The area of a right angled triangle is one-half the product of the base times the altitude or

$$\frac{\text{Base x Altitude}}{2}$$

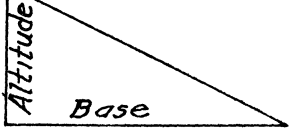

Figure 4.

Example—In Figure 4, assume the altitude to be 50 feet and the base 865 feet, then

$$\text{Area} = \frac{450 \times 865}{2} = \frac{389250}{2} \quad 194625$$

$$\text{Number of acres} = \frac{194625}{43560} = 4.5$$

3. Two Sides Parallel

The area of a field with two sides parallel is figured by taking the average of the two parallel sides and multiplying by the perpendicular distance between them. Expressed as a formula, and referring to Figure 5:

$$\text{Area} = H \times \frac{B + B_1}{2}$$

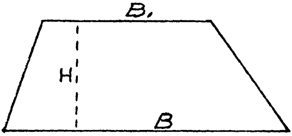

Figure 5.

Caution—H must be measured at right angles to B and B_1.

Example—Assume, in Figure 5, that B = 1000 feet, B_1 = 800 feet and H = 175 feet:

$$\text{Area} = 175 \times \frac{1000 + 800}{2} = 157{,}500$$

$$\text{No. Acres} = \frac{157500}{43560} = 3.6+$$

4. Triangle.

In figuring the area of a triangle, there are two methods which may be used; one in which the computations are simple but in which the results are apt to be slightly in error, and one in which the computations are more involved, but which gives accurate results.

First method—(Altitude method)

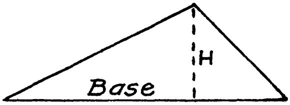

Figure 6.

By this method the area is one-half the base times the altitude H, as shown in Figure 6. For accurate results, H must be at right angles to the base, and must intersect the opposite angle as shown. In field practice this may be difficult to determine exactly.

A good method of erecting perpendiculars is given at the end of this bulletin.

Second Method—(Three side method)

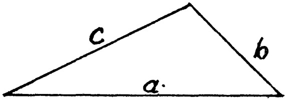

Figure 7.

This is the exact method. In using it, the three sides of the triangle (A, B and C, Figure 7) are measured. Expressed as a formula, this method is as follows:

$$\text{Area} = \sqrt{S\,(S-A)\,(S-B)\,(S-C)}$$

The factor "S" is one-half the sum of the three sides, or, $S = \frac{A+B+C}{2}$

After obtaining S, subtract from it in succession the lengths of A, B, and C. Next multiply four numbers, which are S and the three numbers resulting from the above subtractions. The area is the square root of this product.

Example—Assume that in Figure 7, A=560 feet; B=326 feet; and C=450 feet.

$$\text{Then, } S = \frac{A+B+C}{2} = \frac{560+326+450}{2} = \frac{1335}{2} = 668$$

$$\text{And, Area} = \sqrt{S\,(S-A)\,(S-B)\,(S-C)}$$

$$= \sqrt{668\,(668-560)\,(668-326)\,(668-450)}$$

$$= \sqrt{668 \times 118 \times 342 \times 218}$$

$$= \sqrt{5{,}869{,}346{,}544} = 76612 \text{ square feet}$$

$$\text{Number of acres} = \frac{76612}{43560} = 1.8-$$

5. Four Sides, None Parallel

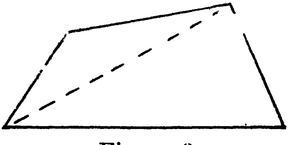

Figure 8.

An area of this type is figured by measuring the sides and a diagonal, as shown by the dotted line in Figure 8. This reduces the area to triangles, all sides of which are known. The area of each may be figured by one of the methods given in Division 4, and the areas added to secure the total.

6. More than Four Sides

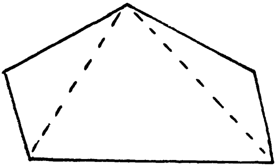

Figure 9.

As long as the sides are straight lines, any area with four or more sides, either regular or irregular, may be reduced to triangles by diagonal lines. This is illustrated in Figure 9. The area of such a field is the sum of the areas of the triangles.

7. Area with Curved Boundary

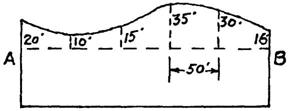

Figure 10.

In case one part of the boundary of a field is an irregular or curved line, one or more straight lines, such as A—B in Figure 10, should be laid off. Offsets perpendicular to A—B as shown by the short dotted lines, and at UNIFORM intervals, should be measured. The area between the line A—B and the curved boundary is measured as follows: Take the sum of the two end offsets and divide by two. To this add the sum of all the other offsets, and multiply by the UNIFORM DISTANCE between the offsets.

As an example, assume that the length of the line A—B in Figure 10 is 250 feet, and the length of the offsets is 20, 10, 15, 35, 30, and 16 feet as shown. The uniform spacing between offsets is 50 feet.

$$\text{To find the area,} \frac{20+16}{2} = 18$$

$$\text{Then } 18+10+15+35+30 \quad 108$$

$$\text{Area} = 108 \times 50 = 5400 \text{ square feet}$$

$$\text{Number of acres} = \frac{5400}{43560} = .1+$$

The area of the remainder of the field is calculated according to its shape, by one of the methods already explained.

If part or all of the curved boundary falls inside the line A—B, the area thus inclosed must be subtracted from the total area.

Erecting a Perpendicular to a Given Line

In measuring the altitude of a triangular field, and for other purposes, it often becomes necessary to erect a perpendicular to a line. One of the simplest and most accurate methods of doing this, when only a tape or chain is available, is known as the equilateral triangle method, and may be explained by reference to Figure 11.

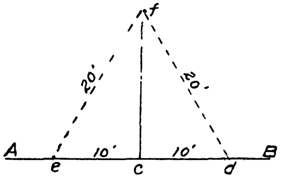

Figure 11

Let AB be the given line to which a perpendicular is to be erected at some point c. Set a pin at c. By measurement and careful sighting, set 2 points d and e on the line AB which are some equal distance from c, and on opposite sides of c. Now hold the 0 point of the tape on d and hold the tape at e on some point on the tape which is greater than the distance from e to d. By having a third man hold the tape at the mid point of this section of the tape and pulling it so that both sides are tight, a point, f, will be located, and a line drawn from f to c will be perpendicular to the line AB.

For example—Measure both ec and cd 10 feet long. Hold the O point of the tape at d and the 40-foot point at e. Let the third man hold the 20-foot point on the tape and pull each side tight. This will locate the point f, and the line fc is perpendicular to AB.

It is advisable to use as large measurements as possible, as the larger measurements, other things being equal, allow more accurate results. After the perpendicular is erected, it may be projected as far as is desired.

This method is valuable, not only in the measurement of areas, but in the laying off of buildings and for numerous other purposes.

In measuring the altitude of triangles, it will in most cases be necessary to erect a perpendicular on the base of the triangle and project it through the apex to obtain the altitude. In doing this it will be necessary to estimate the location of the point on the base line at which the perpendicular should be erected. In case this perpendicular, when projected, does not intersect the apex of the triangle, the point may be moved the necessary distance and a second try made. This second try will ordinarily be all that is necessary.