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HOW TO CALCULATE FIELD AREAS

by
Ray W. Carpenter and C. E. Wise, Jr.

(Reprint of a Bulletin originally prepared for and published by the University of Maryland, Extension Service, College Park, Maryland).

Always valuable, the ability to measure the number of acres in fields has been greatly increased in importance by the Crop Production Control measures of the Agricultural Adjustment Administration. The purpose of this circular is to explain methods for calculating the acreage of fields of various shapes.

UNITS OF MEASUREMENT.

The common units of distance used in land measurement are the foot, the yard, the rod, and the chain.

1 yard	=	3 feet
1 rod	=	$16\frac{1}{2}$ feet
1 chain	=	66 feet

For the purpose of figuring land areas, all measurements of distance should be horizontal or subsequently reduced to horizontal distances. It will usually be more convenient to measure on the surface of the ground and then, where necessary, correct these measurements to horizontal distances by means of Table 1.

The slope, or grade, of the ground surface is usually expressed as the percentage which the vertical rise is of the horizontal distance. For example, a 12% grade is one where the ground surface rises 12 feet vertically in 100 feet of horizontal distance.

The grade for a given slope may be found by taking a 10 foot board and holding it in a horizontal position, with one end on the ground surface. A carpenter's level should be used in this operation. The distance from the other end of the board to the ground, multiplied by 10, will give the grade, in percentage, of the ground surface.

Table 1 shows, for different grades, the surface distances corresponding to horizontal distances of 100 feet, and also the percentages by which measured surface distances should be reduced to obtain the horizontal distance. It will be seen from the Table that for grades below 15% this correction is very small, so small that it may be disregarded unless extremely accurate results are desired.

TABLE 1.

GRADE	"SURFACE DISTANCE"	"CORRECTION"
5%	100.1 feet	0.1%
10%	100.5 "	0.5%
15%	101.1 "	1.1%
20%	102.0 "	2.0%
25%	103.1 "	3.0%
30%	104.4 "	4.2%
40%	107.7 "	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 15% grade a ground surface measurement of 1,125 feet is made. The corresponding horizontal distance is 1,125 minus 1.1% of 1,125 or 1,113 feet. The latter figure should be used for acreage calculations.

UNITS OF AREA.

The universal unit of field area is the acre.

1 acre	=	43,560 sq. ft.
	=	4,840 sq. yds.
	=	160 sq. rods
	=	10 sq. chains

The number of acres in a given field is, therefore, the number of square feet divided by 43,560, square yards divided by 4,840, square rods divided by 160, or square chains divided by 10. In formula form, these rules are expressed as:

$$\text{No. of acres} = \frac{\text{Square feet}}{43{,}560}$$

$$= \frac{\text{Square yards}}{4{,}840}$$

$$= \frac{\text{Square rods}}{160}$$

$$= \frac{\text{Square chains}}{10}$$

Different shapes of fields will now be considered separately.

SHAPE 1. RECTANGLE

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

Assume, in Figure 1, a width of 360 ft. and a length of 570 ft. Then,

$$\text{Area} = 360 \times 570 = 205{,}200 \text{ sq. ft.}$$

$$\text{No. of acres} = \frac{205{,}200}{43{,}560} = 4.71$$

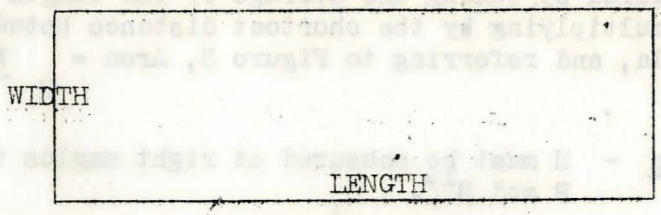

Figure 1.

The dimensions of this field may have been measured in yards, in which case they would be 120 yards and 190 yards. In this case,

$$\text{Area} = 120 \times 190 = 22{,}800 \text{ sq. yds.}$$

$$\text{No. of acres} = \frac{22{,}800}{4{,}840} = 4.71 \text{ as before.}$$

The unit used in measuring the dimensions of a field is immaterial, so long as the resulting area is divided by the proper factor for reducing it to acres.

SHAPE 2: RIGHT TRIANGLE

The area of a right angled triangle is one-half the product of the base times the altitude, or $\frac{\text{Base} \times \text{Altitude}}{2}$

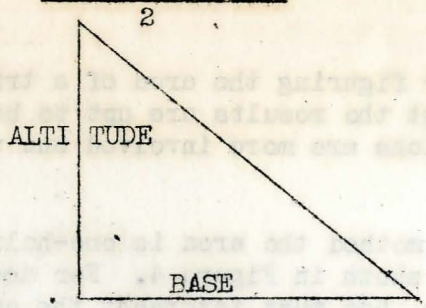

Figure 2.

Assume, in Figure 2, the altitude to be 560 feet and the base 935 feet. Then,

$$\text{Area} = \frac{560 \times 935}{2} = 261{,}800 \text{ sq. ft.}$$

$$\text{No. of acres} = \frac{261{,}800}{43{,}560} = 6.01$$

SHAPE 3. TWO SIDES PARALLEL

This area is figured by taking the average of the length of the two parallel sides, and multiplying by the shortest distance between them. Expressed as a formula, and referring to Figure 3, Area = $H \frac{B + B^1}{2}$

Caution - H must be measured at right angles to B and B^1.

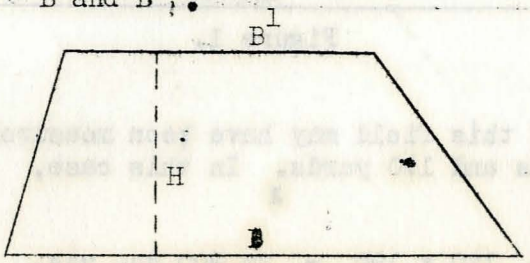

Figure 3.

Assume, in Figure 3, that B = 1,200 ft., B^1 = 960 ft., and H = 480 ft. Then,

$$\text{Area} = 480 \times \frac{1{,}200 + 960}{2} = 518{,}400 \text{ sq. ft.}$$

$$\text{No. of Acres} = \frac{518{,}400}{43{,}560} = 11.90$$

Shape 4. TRIANGLE

There are two methods for figuring the area of a triangle, one in which the calculations are simple but the results are apt to be slightly in error, and one in which the calculations are more involved but which gives accurate results.

First Method. By this method the area is one-half the product of the base times the altitude H, as shown in Figure 4. For accurate results H must be at right angles to the base, and must intersect the opposite angle. In field practice this may be difficult to determine exactly.

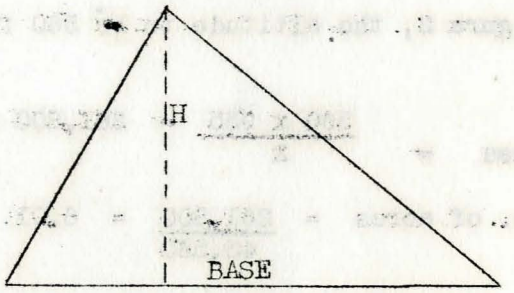

Figure 4.

Second Method. This is the exact method. To use it the three sides of the triangle are measured. These sides are designated as "a", "b", and "c". Next a factor, "s", is calculated. "s" is one-half the sum of "a", "b", and "c", or

$$s = \frac{a + b + c}{2}$$

The next step is to subtract from "s", in succession, the lengths of "a", of "b", and of "c". Next multiply four figures, which are "s" and the three figures resulting from the above subtractions. The area is the square root of this product.

In formula form, this rule is,

$$\text{Area} = \sqrt{s \ (s - a) \ (s - b) \ (s - c)}$$

An example should simplify this somewhat complicated looking rule.

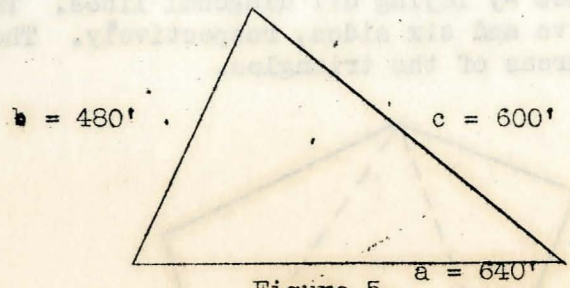

Figure 5.

Assume that, in Figure 5, a = 640 ft., b = 480 ft., and c = 600 ft. Then,

$$s = \frac{640 + 480 + 600}{2} = 860, \text{ and,}$$

$$\text{Area} = \sqrt{860 \ (860 - 640) \ (860 - 480) \ (860 - 600)}$$

$$= \sqrt{860 \times 220 \times 380 \times 260}$$

$$= \sqrt{18,692,960,000}$$

$$= 136,722 \text{ sq. ft.}$$

$$\text{No. of Acres} = \frac{136,722}{43,560} = 3.14$$

SHAPE 5. FOUR SIDES, NONE PARALLEL

An area of this type is figured by measuring the sides and a diagonal, as shown by the dotted line in Figure 6. This reduces the figure to two triangles with all sides of each known. Each triangle is now figured by one of the methods explained under Shape 4, above, and the areas added to secure the total.

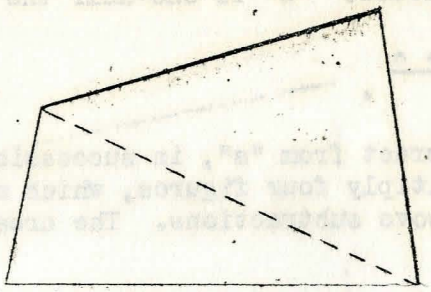

Figure 6.

SHAPE 6. MORE THAN FOUR SIDES

So long as the sides are straight lines, any area with four or more sides may be reduced to triangles by laying off diagonal lines. This is illustrated in Figures 7 and 8 for five and six sides, respectively. The area of the field is the sum of the areas of the triangles.

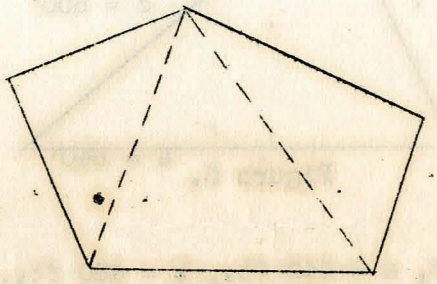

Figure 7

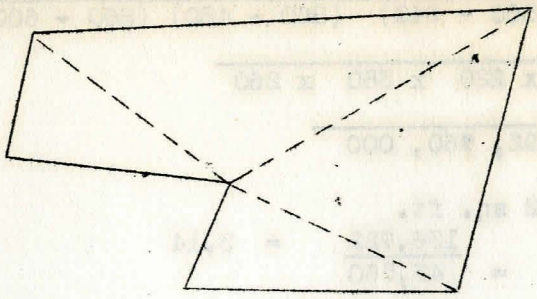

Figure 8

Fields with seven or more straight sides are handled in the same way, except that additional diagonals must be measured.

SHAPE 7. CURVED BOUNDARY.

In case a part of the boundary of a field is irregular or curved, one or more straight lines should be laid off such as A - B in Figure 9. Offsets perpendicular to A - B and at uniform intervals along A - B should be measured, as shown by the short dotted lines. The area enclosed by A - B and

and the curved line is figured by adding together all of the offsets, and multiplying this sum by the uniform spacing between offsets.

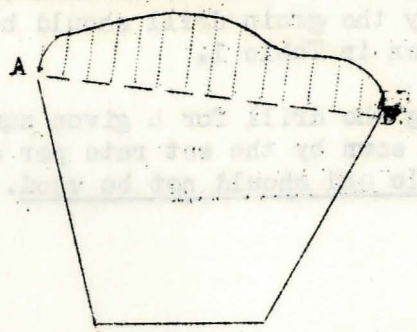

Figure 9

To illustrate this rule assume, in Figure 9, that: (1), the distance A - B is 700 feet, (2) the uniform distance between offsets is 50 feet, (3) the offsets measure, in order, 80, 110, 115, 90, 70, 40, 15, 20, 25, 60, 75, 60, and 35 feet. Then, the sum of the offsets is 795 and,

$$\text{Area} = 795 \times 50 = 39{,}750 \text{ sq. ft.}$$

$$\text{No. of acres} = \frac{39{,}750}{43{,}560} = 0.91$$

The area of the balance 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 enclosed must be subtracted from the total area.

GRAIN DRILL MEASUREMENT.

Most grain drills are equipped with a land measure, or surveyor, which is driven by the main axle. Care should be taken to see that this device is so adjusted that it operates only when the drill is in gear.

It is well to check the accuracy of this device before using it for important acreage measurements. This may be done by running the drill the distance necessary to sow exactly one acre, and noting the land measure readings. Sometimes it is more convenient to jack up one drill wheel, and turn it as many turns as corresponds to one acre.

To illustrate, assume a 12 x 7 drill, with drive wheels four feet in diameter. The width of strip sown is 12 x 7 = 84 inches, = 7 feet. Distance traveled in sowing one acre is 43,560 ÷ 7 = 6.223 ft.

If one wheel is jacked up and turned by hand we must know what distance would be traveled in one revolution. This, for the drill assumed would be 4 x 3.1416 = 12.57 ft. Dividing 6.223 by 12.57 gives 495 revolutions corresponding to one acre.

It should be remembered that any area shown by a grain drill measurement is based upon surface distances. For fields with considerable slope, therefore, the area recorded by the grain drill should be reduced by the proper correction factor, as shown in Table 1.

The method of setting the drill for a given number of pecks per acre, and dividing the total amount sown by the set rate per acre to obtain the acreage of the field, is unreliable and should not be used.

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