“One-thousandth of an acre: the measurement of areas”

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One-thousandth of an acre: the measurement of areas

Chris Higley

David Archer, as always, provided an elegant musing in Sheetlines 115. In it he discusses the acreages of parcels of land, which were for many years shown to a heroic three decimal places on OS 1:2500 plans (Figure 1).

Seymour notes that in 1959 automated methods of computation were trialled and it was decided in future to round parcel areas to two decimal places rather than three. While this was notionally to suit the new equipment, he admits, ‘the value of the third figure had always been doubtful’.¹ This raises two questions. Why was the third figure ever used and why, given that it was known to have uncertain validity, did its use continue for so long?

Areas were not calculated by the surveyor on the ground but instead were computed from the plan after field boundaries had been drawn. The method used looks back to the ancient open field system of agriculture. If a field is divided into strips one chain wide, a strip one furlong long makes up a ‘perfect acre’.² The area of the field in acres can therefore be found by simply adding up the lengths of all the strips in furlongs.

We can divide a parcel into strips on paper by laying over the plan a sheet of tracing paper or acetate ruled with parallel lines a scale distance of one chain apart (figure 2).

In practice the ‘trace’ is ruled in both directions to form a grid of squares, so we could estimate the area of the parcel by counting the number of squares which fall within it. Far better is to use a ‘computing scale’ to sum the lengths of parallel strips.

Palmer describes this as ‘a beautiful and simple contrivance, invented by an

² 22 yards = 1 chain; 10 chains = 1 furlong; 8 furlongs = 1 mile. 1 acre = 4840 square yards or 4046.856 m². The acre was historically divided into 4 roods, and each rood into 40 perches.
employé of the department. My thanks to David Archer for the loan of a typical computing scale (figure 3).

As can be seen, the instrument looks rather like a slide rule. This example is graduated for use on a six-inch plan.

The cursor is set to zero and the scale laid along the first strip to be measured, with the index wire placed over the left-hand end of the strip. The exact starting position is estimated by a ‘give and take method’, as shown by the red lines in figure 2: the grey areas omitted from the calculation are balanced by the additional green areas included.

Holding the computing scale firmly in place, the cursor is moved along the scale until the wire is over the right-hand field boundary. Without adjusting the cursor, the scale is moved down to the next strip and the operation repeated until the lengths of all the strips covering the field have been added together. The total area is then read directly from the scale. As shown in figure 4 the scale is graduated to give a reading in acres, roods and perches. Decimal parts of a perch may be estimated by eye.

By using different graduations on the scale, we can read the area of the parcel in any units we like. I am very grateful to John Wilks for figure 5 and for confirming that, up to the mid-1960s, Ordnance Survey used traces with a 20m grid and computing scales like the one shown. This gives a direct reading in acres,

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3 Captain H S Palmer RE, The Ordnance Survey of the Kingdom, London: Edward Stanford, 1873. Seymour records that the sapper who invented the method received a reward of 6d a day extra pay for the remainder of his service.

4 If the size of the parcel exhausts the capacity of the upper scale, the cursor may be moved back from right to left using the graduations on the lower half.
tenths of an acre and hundredths of an acre without further calculation. Again, the third decimal place could be estimated by eye.

From personal experience, John goes on to say, ‘This method proved to be very accurate ..., however it was very time consuming.’ This echoes Maling’s commendation that scale and trace was so reliable ‘in skilled hands’ that it remained the only method of measuring areas on the basic scale Ordnance Survey maps for more than a century.\(^5\)

However accurate the method used, there are problems inherent in any procedure that calculates parcel areas from the plan. An acre is 4840 square yards or, as some of us were taught at school, ten square cricket pitches. Hence .001 of an acre is tiny, 4.84 sq. yds., one-tenth of a square cricket pitch or about 4m\(^2\). Just because the third decimal place can be estimated from the computing scale reading, it does not mean that it is valid to do so.

Consider the parcel area of 4.370 acres given as an example in the marginal note quoted in David Archer’s *Kerry Musing*. We may assume that this is a square field. Palmer, describing the scale and trace method in 1873, notes ‘In consequence, however, of the daily expansion and contraction of the paper, absolute accuracy can seldom be attained, and a small percentage of error, about 0.2 per cent is allowed’. For our field, this amounts to a potential error in the calculated area of a little over 0.008 acres.

As well as this, the plan will only be measured by human eye to an accuracy of, at the very best, 0.1mm. We get a similar error in the parcel area if we assume that the measurement of just one side of the field is out by this amount, equivalent to ±0.25m on the ground.\(^6\)

Separately and together these calculations show that the third decimal place in the area measurement is essentially meaningless.

But this is not the end of the difficulties. We also have to consider that small irregularities in the field boundary will not be shown on the plan; hedges and fences are shown as having zero width, etc, etc, …

Rob Wheeler makes the very valid point that as land surveyors were accustomed to quoting areas in perches (and sometimes fractions of a perch), customers would not have been happy if Ordnance Survey had shown parcel areas with less precision than this.\(^7\) The computing scale could be read to one-thousandth of an acre and consequently OS would be under strong pressure to use that third decimal place.

Also, 1:2500 County Series plans measured 1½ miles by 1 mile and hence each covered an area of 960 acres. The general public are not comfortable with rounding errors: OS ‘adjusted’ some parcel areas after computation so that the total of all parcel areas on each sheet came to exactly 960 acres. This fudging would have been less apparent if the third decimal place was available, rather


\(^6\) J B Harley, *Ordnance Survey Maps, a descriptive manual*, Southampton: Ordnance Survey, 1975, confirms that ±0.25m is, in any case, a good deal smaller than the surveying error regarded as acceptable on 1:2500 plans.

\(^7\) Private communication.
than changes having to be made to the second.

The plan maps the ground as if it were level. Suppose that our field slopes at an inclination of 1 in 20. This means that field boundary running up the slope will actually be slightly longer on the ground than implied by the length of line representing it on the plan. Not a huge amount, but enough to increase the parcel area from 4.370 acres on the plan to 4.375 acres on the sloping ground. Captain H S Palmer, an officer of the Ordnance Survey writing in 1873, is worth quoting at length on this subject:

‘To attempt to roll the country out flat – in other words, to take account of inclinations of the ground in the delineation of features, or the calculation of areas – would be to defy all principles of accurate map-making, and to pass beyond all limits by which areas can be checked. The horizontal system, therefore, as the only one applicable to a general national map, is that which has been adopted for the Ordnance Survey. We believe, moreover, that it is the best and truest system. The produce of land, and therefore its real value for sale, or letting, or taxation, are, if we mistake not, directly proportional to its horizontal area. Then, as regards tillage and labour on the land, it can hardly be doubted that both employers and employed would benefit in the long run by adopting as the final basis of agreement the areas given by the Ordnance maps. They would certainly gain in the prompt settlement of disputes, and in the saving of the sums now so constantly paid for land-measurements to local surveyors. And although the labourer or ploughman who works by the acre may naturally prefer to be paid according to the superficial rather than the horizontal measurement of sloping land, and will doubtless imagine, when he comes to think about the matter, that he is a considerable gainer by that mode of reckoning, the difference between the two is in reality extremely small, very much smaller, indeed, than is generally supposed, seldom exceeding two or three per cent. on the steepest slopes that can well be cultivated.’

The defensive tone is notable; we hear a similar voice when revision work is being discussed in Instructions for computation and examination of areas, 1907: 8

‘The great principle [the computer] has to remember is that old unaltered areas are not to be tested or computed, but are to be accepted as correct, unless there is a strong reason to suspect an error.’

‘Parcel areas should not be altered if there has been no alteration in detail on the ground. But when the original area is found to be in error, it will be corrected, if the circumstances of the case warrant this being done. Small alterations in old areas should be avoided, as such will destroy confidence in the Survey work generally.’

The conclusion is that it is not possible to measure field areas with absolute accuracy, but that this does not matter provided that an independent authority has defined the parcel to have a particular area and the figure given cannot be

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8 Ordnance Survey, Instructions for computation and examination of areas, 1907. My thanks to Richard Oliver for sight of this document. A copy is held by The National Archives (OS 45/5).
disproved. If there is dispute between buyer and seller, landlord and tenant, land owner and tithe collector, the fact that the Director General of the Ordnance Survey has impartially certified the area of a field to three places of decimals of an acre will be accepted by both sides without further argument.

However, in the same way that a Bank of England note will only retain its value if everyone has faith in it, confidence in OS area measurements is only maintained by their not being subject to arbitrary change. As the computer scientist, Professor David Wheeler, once put it, ‘The pursuit of compatibility consists of deliberately not putting right other people’s errors’.  

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**Diamonds are forever … getting me lost!**

This green diamond symbol seems to be casually strewn across the countryside on Explorer maps with little regard to the actual presence of a way on the ground. The use of occasional chunky lozenges to depict a continuous linear route is not only unhelpful for navigation, but also creates ugly clutter on the map, as these two examples from Epping Forest illustrate. The single marker on the south-bound fork of the Three Forests Way offers no help in locating the point at which to leave the main track, whilst the apparent direct line from the A503 to the A104 actually crosses fenced allotments and a bog.

Surely the cartographers could devise a suitable continuous coloured line which would look neater on the map and provide clear navigational information?

*Ramblin’ Jack*

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9 In a lecture on computer system design about fifty years ago.