COMMENTS

Agricultural Productivity in Eighteenth-Century England: Some Further Speculations

By MARK OVERTON

Dr Turner's new estimates of national crop yields per acre at the turn of the eighteenth century are to be welcomed. Although they are broadly similar to the figures we already have (his average of 19·5 bushels per acre compares with Fussell's 22 and McCulloch's 21) they do seem to be based on more reliable sources.[1] Further, Turner's speculations about changes in wheat yields during the eighteenth century add another voice to the existing complaints about Deane and Cole's assertion of a 10 per cent rise.[2] However, lest Turner's conclusions become "fossilized", as he thinks Deane and Cole's have become,[3] this comment is directed at certain misleading assertions he makes about trends in yields per acre. In an attempt to resolve some of these difficulties the earlier estimates are re-examined, leading to the conclusion that existing national estimates of wheat yields in England between *c.* 1650 and *c.* 1770 cannot form a suitable basis for evaluating either the magnitude or the trend of yields during the course of the eighteenth century.

I

Using three Government surveys (the Home Office returns for 1795-6 and 1801, and the House of Lords Enquiry made in 1800), Turner provides us with three estimates of mean wheat yield for specific years (1794, 1795 and 1801) and two estimates for an "average year", made in 1795 and 1800.[4] These estimates are based on a reasonably large number of individual figures and are thus probably more reliable than existing estimates. However, Turner's national means accord equal weight to each unit (a county or a parish) to which the individual figures refer. To compensate for variations in the size of

[1] M. Turner, 'Agricultural Productivity in England in the Eighteenth Century: Evidence from Crop Yields', *Economic History Review*, 2nd ser. XXXV (1982), pp. 489-510.

[2] P. Deane and W. A. Cole, *British Economic Growth, 1688-1959* (Cambridge, 2nd edn. 1969), pp. 67-8; M. Overton, 'Estimating Crop Yields from Probate Inventories: An Example from East Anglia, 1585-1735', *Journal of Economic History*, XXXIX (1979), p. 375; N. F. R. Crafts, 'Economic Growth in the Eighteenth Century: A Re-Examination of Deane and Cole's Estimates', *Econ. Hist. Rev.* 2nd ser. XXIX (1976), pp. 226-35; N. F. R. Crafts, 'Income Elasticities of Demand and the Release of Labour by Agriculture during the British Industrial Revolution', *Journal of European Economic History*, 9 (1980), pp. 153-68.

[3] Turner, 'Agricultural Productivity', p. 490.

[4] These are summarized in his Table 3, ibid. p. 501. The data from which his mean yields are calculated are given on pp. 506-10. Although data for the yields of barley and oats are presented these are not discussed in his article, and this comment will only be concerned with wheat yields.

these units each figure should be weighted in proportion to the area to which it refers in calculating the means.[5] Further, although Turner speaks of 'the problem of variance' he does not provide any estimates of the variances of the distributions of yields.[6] Although the variances of distributions based on county figures alone can be calculated from the data in the Appendix to his article, those based on parish figures cannot.

Having presented his new estimates for *c.* 1800, Turner then compares them with earlier estimates of wheat yields, using the figures produced by Fussell, Bennett, and Young. He concludes with "confidence" about changing crop productivity over the eighteenth century: "this productivity change was greatly in excess of the popularized 10 per cent, and we may rightly place the period of greatest productivity change before 1770."[7] This statement is rather surprising since the two claims made — the first about the rate of productivity change and the second about the period of most rapid change — depend on contradictory interpretations of the evidence. As Turner says, "two approaches can now be made", the first (leading to his first claim) involves "leaving to one side for the moment the Fussell and Young estimates", while the second approach (leading to the second claim) involves "adopting the Fussell and Young estimates".[8] In fact his first approach involves accepting Bennett's figure of 11 bushels per acre for the late seventeenth century and rejecting Fussell's figure of 20, while the second approach relies on rejecting Bennett's mid-century figure and accepting Young's estimate of 23 bushels for *c.* 1770. Table 1 shows the percentage increases in wheat yields over the three periods with which Turner is concerned (*c.* 1700 to *c.* 1800, *c.* 1700 to *c.* 1760, and *c.* 1760 to *c.* 1800) using his new figure of 19·5 bushels per acre (rounded to 20) together with the estimates of Bennett, Fussell, and Young. For each period there are four possible percentage increases, given that there are two yield estimates at both the beginning and end of each period. The annual average percentage increases are given in addition to the overall rates, since the latter are misleading if comparisons are drawn between periods of unequal length. It is evident from Table 1 that the conclusion that wheat yields rose over the

[5] This general point is discussed by J. A. Venn, *The Foundations of Agricultural Economics* (Cambridge, 2nd edn. 1933), p. 435. Symbolically, Turner's national yield for a particular crop is calculated as

$$\frac{1}{n}\sum_{i=1}^{n}\frac{Y_i}{X_i}$$

where Y is output in bushels, X is acreage, for n parishes or counties, or a combination of parishes and counties. An estimate of national yield should be calculated as

$$\frac{\sum_i^n Y_i}{\sum_i^n X_i} \quad or \quad \sum_i^n \frac{Y_i}{X_i}\,\frac{X_i}{\sum_i^n X_i}$$

that is, total output divided by total acreage, or output divided by area for each unit weighted by the area of that unit as a proportion of total area. The weighted and unweighted means are equivalent when yield is constant for all areas, when area is constant, and when the covariance of area and yield is zero.

[6] Turner, 'Agricultural Productivity', p. 502.

[7] Ibid. p. 506.

[8] Ibid. pp. 503-4.

Table 1. *Percentage Increases in Wheat Yields, c. 1700-c. 1800, c. 1700-c. 1760 and c. 1760-c. 1800*

A. c. 1700-c. 1800

c. 1700 Estimate		*c. 1800 Estimate*		*Annual Average Percentage*	*Overall Percentage*
Fussell	(20)	Turner	(20)	0·0	0
Fussell	(20)	Fussell	(22)	0·10	10
Bennett	(11)	Turner	(20)	0·60	82
Bennett	(11)	Fussell	(22)	0·70	100

B. c. 1700-c. 1760

c. 1700 Estimate		*c. 1760 Estimate*		*Annual Average Percentage*	*Overall Percentage*
Fussell	(20)	Bennett	(15)	−0·48	−25
Fussell	(20)	Young	(24)	0·30	20
Bennett	(11)	Bennett	(15)	0·52	36
Bennett	(11)	Young	(24)	1·31	118

C. c. 1760-c. 1800

c. 1760 Estimate		*c. 1800 Estimate*		*Annual Average Percentage*	*Overall Percentage*
Young	(24)	Turner	(20)	−0·45	−17
Young	(24)	Fussell	(22)	−0·22	−8
Bennett	(15)	Turner	(20)	0·72	33
Bennett	(15)	Fussell	(22)	0·96	47

Note: The figures in brackets after the authorities' names are their estimates of wheat yield in bushels per acre.

Sources: Yields as given in Table 5 of M. Turner, 'Agricultural Productivity in England in the Eighteenth Century: Evidence from Crop Yields', *Econ. Hist. Rev.* 2nd ser. XXXV (1982), p. 504. I disagree with the dates ascribed by Turner to the estimates of Bennett. Gregory King's figures refer to the 1690s and not to 1650; M. K. Bennett, 'British Wheat Yields Per Acre for Seven Centuries', *Economic History*, 3 (1937), p. 23; and Charles Smith's refer to the early 1760s and not to 1750; Bennett, 'British Wheat Yields', p. 24. Young's estimates probably refer to an average for the 1760s and not to *c.* 1770 since his *Tours* were published between 1768 and 1771 and he was referring to average yields on particular farms rather than to the yield for a specific year. I use Turner's recalculated figure of 24 rather than Caird's figure of 23; Turner, 'Agricultural Productivity', p. 499 n. 49.

century by more than 10 per cent depends on the assumption that Fussell's figure of 20 for *c.* 1700 is too high. Turner's second claim, that the period of greatest productivity change was before *c.* 1760, depends on the *c.* 1760 estimate, and, judging by his conclusion, he assumes Young's is more accurate than Bennett's. Before Turner's conclusions can be accepted these assumptions must be vindicated.

Unfortunately, while Turner comments on the accuracy of the various estimates he comes to no conclusions as to which are to be trusted, and he fails to give his reasons for picking the estimates on which his conclusions rest. Indeed, the task of discriminating between the pre-1800 estimates is a daunting one. However, given they have been accepted without serious question for almost 50 years,[9] they deserve some re-examination. Both Bennett and Fussell found it impossible to resist the temptation of adjusting their estimates to their prior conceptions about the progress of agricultural technology,[10] so that arguments about the relationships between agricultural improve-

[9] For example, by C. P. Timmer, 'The Turnip, the New Husbandry, and the English Agricultural Revolution', *Quarterly Journal of Economics*, LXXXIII (1969), pp. 375-95; and J. D. Chambers and G. E. Mingay, *The Agricultural Revolution, 1750-1880* (1966), p. 5.

[10] Overton, 'Estimating Crop Yields', p. 365, comments on Bennett. See also G. E. Fussell, 'Grain Supply in Two Wars: The Napoleonic and the European', *Scientific Agriculture*, XII (1932), pp. 537-8, where he adjusts his yield estimates downward.

ment and grain yields become circular. Moreover, Bennett is forced to make such assumptions since the material he used from Gregory King and Charles Smith made no specific mention of yields per acre. Bennett had to supplement their estimates[11] with his own series of estimates of the average amount of seed sown and the proportion of arable land under wheat. Bennett adopts two strategies towards King's data. Firstly, he multiplies King's yield ratio[12] of 1:5–1:8 by an assumed seeding rate of 2–2·5 bushels per acre to give an estimate of yield ranging from 10 to 20 bushels per acre. Secondly, he uses King's estimate of net wheat output (14 million bushels), adds an allowance for seed, and divides the total by an estimated wheat acreage of 1·75m (derived by working backwards from Comber's 1808 estimate[13]). This second method gives a yield of 10-11 bushels per acre. Bennett arrives at his final figure (11 bushels per acre) by advancing some "defensible hypotheses"[14] about seed rates and King's preferred yield ratios (which in fact he does not defend) and by making assumptions about the likely level of yields, given his pre-conceptions about predominant farming practices and their impact on yields.[15]

While Bennett used only one version of King's estimates (the one reproduced by Davenant) we are now able to consider more material by King which has recently been published. King's estimates of wheat output ranged from 12 million to 14 million bushels and his estimates of arable land from 9 million to 11 million acres.[16] One entry in his *Notebook* suggests a wheat output of 40 million bushels, based on the assumption that wheat yields were 20 bushels per acre.[17] His estimates of seed ratios also fluctuated more widely than Bennett realized, from 1:4 to 1:8.[18] Prof. Holmes has argued convincingly that historians' trust in King's social tables has been misplaced,[19] and the publication of further extracts from King's writings indicates at the very least that his data are inconsistent. If, however, we persevere, accepting Bennett's estimate of 1·75m acres,[20] but raising his seed rate to 2·5 bushels per acre,[21]

[11] He extracted it from secondary sources. For King, Bennett used C. Whitworth, ed. *The Political and Commercial Works of Charles D'Avenant* (5 vols. 1771), pp. 216-17. For Smith, he used W. Ashley, *The Bread of our Forefathers* (Oxford, 1928), pp. 5-8, 24-5; M. K. Bennett, 'British Wheat Yield Per Acre for Seven Centuries', *Economic History*, 3 (1937), pp. 12-29.

[12] The yield ratio is the ratio between the quantity of grain sown and the quantity of grain harvested.

[13] Bennett, 'British Wheat Yield', pp. 22-3; Deane and Cole, *British Economic Growth*, pp. 67-8.

[14] Bennett, 'British Wheat Yield', p. 22.

[15] Ibid. pp. 23-4.

[16] G. E. Barnett, ed. *Two Tracts by Gregory King* (Baltimore, 1936), prints his *Natural and Political Observations* of 1695 (which had already been published). Subsequently extracts from his *Notebook* of 1695 and the 'Kashnor' MS. of 1697 containing agricultural statistics have been published. These are available most conveniently in J. Thirsk and J. P. Cooper, eds. *Seventeenth Century Economic Documents* (Oxford, 1972), pp. 779-83, 765-7, and 796-8. King's figures as recorded by Davenant (and used by Bennett) differ in part from both the *Observations* and the *Notebook*, Whitworth, *Political and Commercial Works of Charles D'Avenant*, pp. 216-17.

[17] Recorded in the *Notebook*, Thirsk and Cooper, *Economic Documents*, p. 766.

[18] Recorded in the *Observations*, Thirsk and Cooper, *Economic Documents*, p. 782; and by Davenent, Whitworth, *Political and Commercial Works*, p. 217.

[19] G. S. Holmes, 'Gregory King and the Social Structure of Pre-Industrial England', *Transactions of the Royal Historical Society*, 5th ser. 27 (1977), pp. 41-68.

[20] This seems as good a guess as any given: M. Turner, 'Arable Acreage in England and Wales: Estimates from the 1801 Crop Return', *Journal of Historical Geography*, 7 (1981), pp. 296-301.

[21] This figure is based on discussions with a farmer who used to broadcast wheat and on A. Young, *A Six Months Tour through the North of England* (2nd ed. 4 vols. 1771), IV, pp. 81-5; A. Young, *The Farmer's Tour through the East of England* (4 vols. 1771), IV, pp. 243-5.

we can use King's figures to show that wheat yields in England and Wales at the end of the seventeenth century lay in the range 8-20 bushels per acre. Short of making guesses on the basis of assumptions about agricultural practice we cannot narrow this range.

Bennett's treatment of Smith's calculations is just as problematic. In fact, all Smith provides is an estimate of wheat consumption in England and Wales at 30 million bushels in the 1760s,[22] based on assumptions about the proportion of the population eating wheaten bread (63 per cent), their per capita consumption of wheat (8 bushels per annum), and the size of the population (5·92 million). Bennett assumes a population of 6·75 million and so increases Smith's figures by 4 million bushels, and calculates gross output by adding seed and exports. He divides this by a new guess at the wheat area (2·5–2·9 million acres) to give a yield estimate of 15–17 bushels per acre.[23] Again Bennett uses a secondary source for his data, seemingly unaware that Smith considered the yield ratio for wheat to be 1:10. When combined with Bennett's seeding rate, this would give a yield of 22 bushels per acre (or, adopting my rate of 2·5 bushels per acre, 25 bushels per acre).[24] Using the alternative method of dividing output by acreage we can employ a new population estimate of 6·72 million,[25] but apart from that no new data are available. Nevertheless, Smith's consumption figures may be too high given Fussell's comments and some nineteenth-century estimates,[26] while the estimate of the proportion of wheat eaters may be too low.[27] Taking the ranges of the various estimates we can arrive at an estimate of wheat yield for the 1760s which ranges from 14 to 27 bushels per acre.[28]

In comparison with these tortuous calculations the estimates of Fussell and Young are derived more simply, since both are based on direct contemporary estimates of yields per acre. Unfortunately, as Turner points out, Fussell's estimates for *c.* 1700 are "only a few regionally disparate ones".[29] Young's for the 1760s on the other hand cover a wide variety of farming conditions for most areas of the country, and were based on visits to a relatively large number of farms.[30] Nevertheless, it is difficult to assess their validity. On the one

[22] Originally published in C. Smith, *Three Tracts on the Corn Trade and Corn Laws* (1766); see n. 11 above p. 247.

[23] Bennett, 'British Wheat Yield', p. 24.

[24] Deane and Cole, *British Economic Growth*, p. 65.

[25] E. A. Wrigley and R. S. Schofield, *The Population History of England, 1541-1871: A Reconstruction* (1981), pp. 208-9. Their English figure is inflated to include an estimate for Wales, ibid. p. 577.

[26] G. E. Fussell, 'Population and Wheat Production in the Eighteenth Century', *History Teachers' Miscellany*, VII (1929), pp. 66-7, puts the figure at 6 bushels per annum; J. B. Lawes and J. H. Gilbert, 'On the Home Produce, Imports, and Consumption of Wheat', *Journal of the Royal Agricultural Society of England*, 2nd ser. 4 (1868), p. 377 put it at 6; S. Fairlie, 'The Corn Laws and British Wheat Production, 1829-76', *Econ. Hist. Rev.* 2nd ser. XXII (1969), p. 110 thinks it should be higher; although E. J. T. Collins, 'Dietary Change and Cereal Consumption in Britain in the Nineteenth Century', *Agricultural History Review*, 23 (1975), p. 115 disagrees. Most estimates lie between 6 and 8 bushels.

[27] Fussell, 'Population and Wheat Production', pp. 86-7 thinks it should be 80 per cent; but Collins, 'Dietary Change', pp. 98-108 puts the figure for England and Wales at 66 per cent for 1800.

[28] Assuming a population of 6·72 million (n. 25 above), of whom 60 per cent (Smith) or 80 per cent (Fussell) eat 6-8 bushels (n. 26 above) of wheat per annum. Net exports at 3·1 million bushels (the mean of annual figures for 1760-4) or 1·1 million bushels (mean of 1760-9) and a yield ratio of 1:6-1:10 (Smith). The acreage of wheat is a guess of 2 million, based on extrapolation backward from Turner, 'Arable Land in England and Wales', pp. 296-301. The export figures are taken from D. G. Barnes, *A History of the English Corn Laws* (New York, 1930), p. 299.

[29] Turner, 'Agricultural Productivity', p. 503; Fussell, 'Population and Wheat Production'.

[30] A. Young, *A Six Weeks Tour, through the Southern Counties of England and Wales* (1768), pp. 242-5; Young, *Six Months Tour through the North of England*, IV, pp. 80-9; Young, *Farmer's Tour through the East of England*, IV, pp. 230-5.

hand, Young reported yields carefully and systematically; also he did not simply record the yields from best-practice farms, since he frequently notes low yields and comments on the bad husbandry he thought responsible for them.[31] And while Young has been criticized by some historians (including Bennett) and abused by others, he has also been defended.[32] On the other hand, even the most conscientious reporter must rely mainly on what farmers choose to tell him, and if eighteenth-century farmers shared the same inclinations as their twentieth-century counterparts, they would have been likely to exaggerate their yields per acre and understate the quantity of seed they sowed. The verdict on Young must therefore remain open.

Table 2. *National Estimates of Wheat Yields in England and Wales, c. 1700-c. 1800*

c. 1700	**Bennett*	11	†*Fussell*	20	‡*King*	8-20
c. 1760	**Bennett*	15	§*Young*	24	‡*Smith*	14-27
c. 1800	¶*Turner*	20	†*Fussell*	22	‖*McCulloch*	21

Sources:

* M. K. Bennett, 'British Wheat Yield Per Acre for Seven Centuries', *Economic History*, 3 (1937), pp. 22-4.

† G. E. Fussell, 'Population and Wheat Production in the Eighteenth Century', *History Teachers' Miscellany*, VII (1929), pp. 65-8, 84-8, 108-11, 120-7.

‡ My estimates discussed in the text.

§ Turner's re-calculated figure, M. Turner, 'Agricultural Productivity in England in the Eighteenth Century: Evidence from Crop Yields', *Econ. Hist. Rev.* 2nd ser. XXXV (1982), p. 499 n. 49.

¶ Ibid. p. 504.

‖ J. R. McCulloch, *A Descriptive and Statistical Account of the British Empire* (1837), p. 482; the figure is based on Board of Agriculture Reports.

As Table 2 shows, this re-evaluation of the evidence of eighteenth-century wheat yields has done nothing to help choose between the various contradictory estimates. Bennett's figure of 11 bushels per acre for the late seventeenth century and Fussell's estimate of 20 have been replaced by a range of 8-20 bushels, and for the 1760s a range of 15-24 is replaced by a range of 14-27 bushels per acre. Further, the bounds of the range for a particular period cannot be interpreted as the limits of a normal distribution (with the mean in the middle). Given the way they have been derived, any figure within the range is equally likely. Thus, far from solving the problem posed by Table 1, we are left with less confidence in statements about the extent and chronology of eighteenth-century wheat yields. Turner's speculations on the relationships between agricultural productivity and population growth, or on the standard of living, are completely without empirical foundation, given the evidence on which he bases them.[33] Indeed, some definitive and unambiguous evidence is still required on the state of eighteenth-century land productivity.

[31] For example, 'execrable', 'very bad', 'bad management', taken from Young, *Farmer's Tour through the East of England*, pp. 230-3.

[32] For example, Fussell, 'Population and Wheat Production', p. 121; D. B. Grigg, 'The Changing Agricultural Geography of England: A Commentary on the Sources Available for the Reconstruction of the Agricultural Geography of England, 1770-1850', *Transactions of the Institute of British Geographers*, 41 (1967), p. 76: Bennett, 'British Wheat Yield', pp. 67-9. The abuse comes from E. Kerridge, 'Arthur Young and William Marshall', *History Studies*, 1 (1968), pp. 43-53; and a defence from G. E. Mingay, *Arthur Young and his Times* (1975), pp. 15-16.

[33] Turner, 'Agricultural Productivity', p. 506.

II

Historians make use of crop yields in trying to answer a variety of questions about the past. Such is the variety of those questions, evidenced by Turner's speculations, for example, that *national* averages, even if such a series could be produced, might not be the most suitable for answering all of them. Some questions can be answered without recourse to yield figures at all. Craft's method of estimating the growth in agricultural output, for example, avoids using yield figures and involves a series of equations which make fewer demands on uncertain data.[34] On a different tack, the relationships between changing agricultural practices, particularly the introduction of fodder crops, such as turnips and clover, can be revealed in part without using dubious evidence of national yields. Chorley, for example, makes considerable use of the Rothamsted field experiments in studying the impact of leguminous crops on north European agriculture, which also provide a path towards understanding the introduction of the Norfolk four-course rotation into English agriculture.[35]

At the local level an alternative series of yields is available for the period 1585-1735 for the counties of Norfolk and Suffolk, which could be extended to other areas of the country with an adequate quantity of probate inventories.[36] Given the assumptions underlying the method by which they are calculated, this series is probably a more accurate reflection of the trend of yields than their absolute level. Even so, the margin of error around the figures is considerably lower than for other available estimates, and can, to some extent, be quantified.[37] These yields can be combined with acreage figures from inventories to give some tentative estimates of changes in mean grain output per farm,[38] and can be related to changes in husbandry techniques, as well as to the short-term influence of the weather.[39]

III

The temptation to assign "authority" to a number, just because it is "quantitative"[40] is sometimes difficult to resist. Further, when faced with

[34] Crafts, 'English Economic Growth'.

[35] G. P. H. Chorley, 'The Agricultural Revolution in Northern Europe, 1750-1880: Nitrogen, Legumes and Crop Productivity', *Econ. Hist. Rev.* 2nd ser. XXXIV (1981), pp. 71-93; M. Overton, 'Agricultural Revolution? Development of the Agrarian Economy in Early-Modern England', in A. R. H. Baker and D. J. Gregory, eds. *Explorations in Historical Geography* (Cambridge, 1984), pp. 125-6, making use of the data in J. B. Lawes and J. H. Gilbert, 'Rotation of Crops', *Jnl. Royal Agric. Soc.* 3rd ser. 5 (1894), pp. 584-646.

[36] Overton, 'Estimating Crop Yields'.

[37] The standard errors of the mean yields shown graphically in ibid. pp. 371-2 can be found in M. Overton, 'Agricultural Change in Norfolk and Suffolk, 1580-1740' (unpublished Ph.D. thesis, University of Cambridge, 1981), p. 77. The yields calculated may be slightly too low. If the valuation of grain per acre excluded the costs of harvesting grain, or tithe payments, then the existing estimates should be inflated by 1·1 ($\bar{u}'+k$), where $\bar{u}'$ is the existing estimate and k the cost of harvesting an acre of grain divided by the valuation of grain per bushel. k is probably slightly less than 1·0.

[38] M. Overton, 'English Probate Inventories and the Measurement of Agricultural Change', *A.A.G. Bijdragen*, 23 (1980), p. 214.

[39] Overton, 'Estimating Crop Yields', p. 376.

[40] Turner, 'Agricultural Productivity', p. 490 ascribes 'quantitative authority' to the yield estimates of Holderness. These have not yet been published, and the unpublished paper in which they appear describes neither the specific sources on which they are based nor the method by which they are calculated.

numbers that are contradictory we should make some reasoned attempt at determining their likely margin of error, thus forming the basis for deciding whether we can accept or reject them. While Turner makes some attempts at evaluating his new yield estimates for *c.* 1800 he fails to discriminate sufficiently between the earlier estimates of Fussell, Bennett, and Young, leaving his speculations about agricultural productivity during the eighteenth century without acceptable empirical foundation. My own verdict on the possibilities of discriminating between them to give yield estimates of sufficient precision to confirm (or refute) his assertions is a pessimistic one. Nevertheless, there are alternative ways, which may be more rewarding, of getting to grips with some of the questions which a series of national yield statistics might answer.

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