THE OPEN UNIVERSITY

ALTERNATIVE TECHNOLOGY GROUP

SMALLHOLDINGS AND FOOD PRODUCTION

An Alternative Strategy
for U.K. Agriculture

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ATG 1

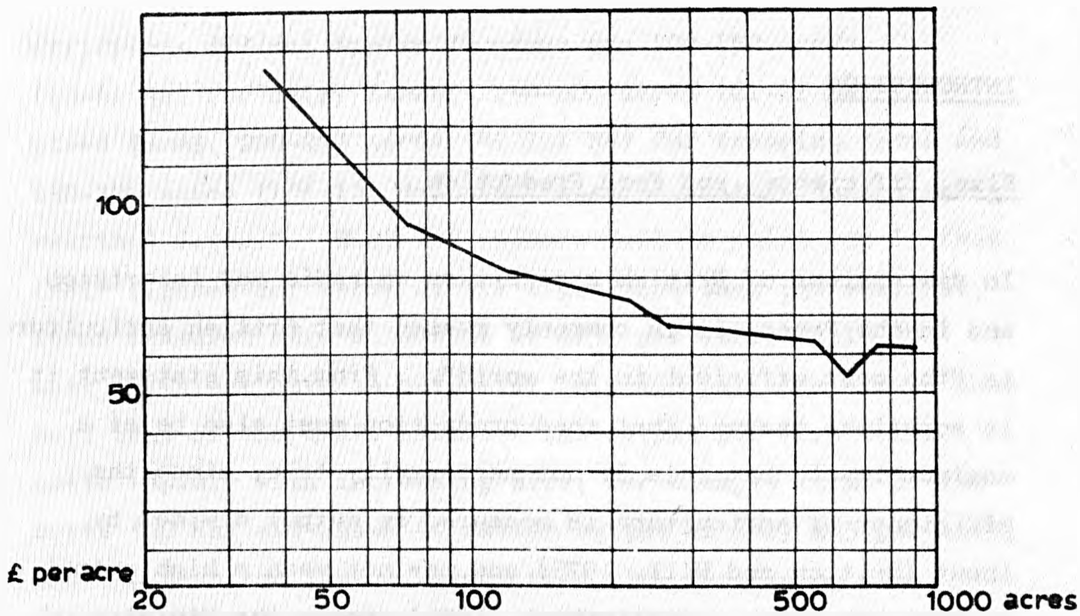

FIGURE I Output per acre by size of Farm
All Farms

BOTH GRAPHS AFTER BRITTON & HILL (1975).

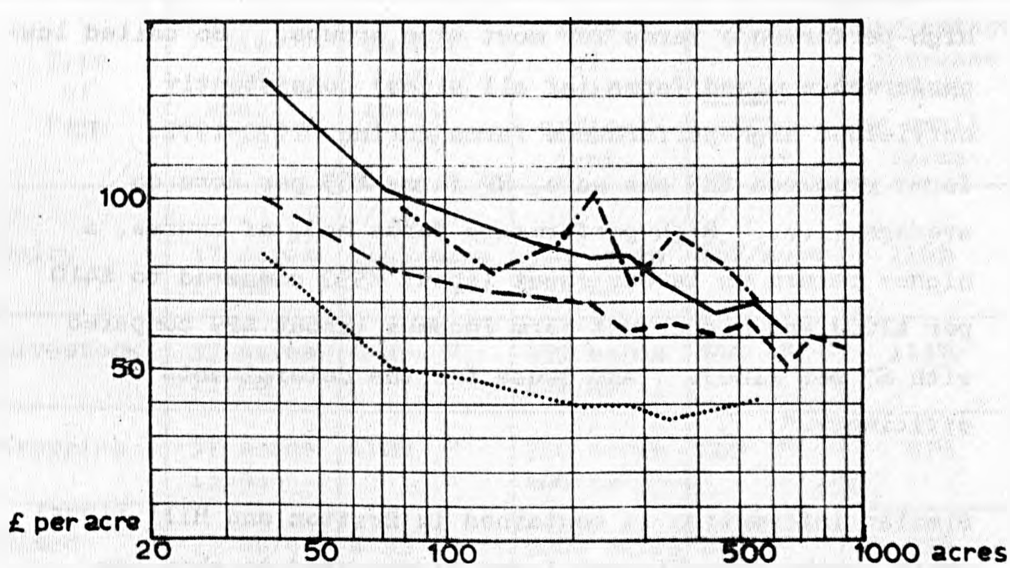

FIGURE II Output per acre by size of farm

Dairy Farms ————

Livestock Farms ....

Cropping Farms ------

Mixed Farms -.-.-.-.-

INTRODUCTION

Size, Efficiency, and Food Production

In discussions of British agriculture on radio and television and in the Press, it is commonly stated that British agriculture is "the most efficient in the world". From this statement, it is sometimes assumed that food production must also be at a maximum level, but this is not necessarily true, since the efficiency of agriculture is measured as output divided by input (Britton and Hill, 1975) and may not mean a high output of food per acre. Clutterbuck (1976) quotes the Ministry of Agriculture's definition of "high-performance (HP) farms - those with the highest ratio of output per £100 input - which have 'higher net incomes, specialise more and have lower labour, rent and machinery costs per acre'; and low performance (LP) farms - the quarter of farms with the lowest such ratio", but he points out that "Low-performance dairy, livestock and croppingfarms produce outputs comparable to those of similar high-performance farms for most size groups. So called low-performance mixed farms (of all sizes) consistently outyielded high-performance farms during 1970-1972. LP farms produced £85 per acre, HP farms £65 per acre on average...... High-performance farms had, of course, a higher return on labour input (about £550 compared to £410 per £100) and higher net farm incomes (about £29 compared with £7 per £100). And these are the determinants of efficiency."

Similar information is contained in Britton and Hill (1975) where graphs (see Figures 1 and 2) are used to show how efficiency ratio rises with increases in farm size (measured in terms of area). For all types of farms in the period 1970-1971 efficiency ratio (output/input) rises to a maximum at 900 acres (364 Ha), although the authors say "the acreage beyond which significant increases in efficiency did not appear to occur was 100-150 acres (40-61 Ha) for dairy farms; 150-200 acres (61-81 Ha) for mixed farms, 200-250 acres (81-101 Ha) for cropping farms and 250-300 acres (101-121 Ha) for livestock (cattle and/or sheep rearing) farms." What the authors fail to point out is that their figures for farms of all types show that the smallest farms measured have an output of £135 per acre, while the most efficient have an output of only £62 per acre - less than half that of the small farms. The output per acre falls quite rapidly with increasing size, for example farms of 100 acres (40 Ha) are shown to have an output of only £85 per acre, showing that the loss of production with increasing size occurs rapidly at the small end of the scale but is less important between 100 and 900 acres (40-364 Ha). When these figures for all types of farms are broken down into types, the results are as shown in Table I.

TABLE I

Type of Farm	Size of smallest	Output of smallest	Size of most efficient	Output of most efficient	Percentage increase shown by small farms
Dairy	37 acres 15 Ha	£145/acre	550 acres 223 Ha	£67/acre	116%
Livestock	37 acres 15 Ha	£ 85 "	450 acres 182 Ha	£40 "	113%
Cropping	37 acres 15 Ha	£100 "	750 acres 404 Ha	£60 "	67%
Mixed	77 acres 31 Ha	£ 95 "	500+ acres 202+ Ha	£75 "	27%

It should be noted that for the category of "mixed" farms, the highest output of £102 per acre occurs at a size of 230 acres (93 Ha), but the graph shows the output rising quite rapidly when it stops at 77 acres, and it could be inferred from the figures for other types of farms that output might be expected to increase with diminishing size for this category of farms as well as the others. If the figures quoted earlier as the sizes of farms beyond which "significant increases in efficiency" do not occur are taken, rather than the sizes shown to be most efficient, there would be some decrease in the percentage advantage shown by small farms, but in most cases the output per acre rises more steeply below the 80 acre size. The exception is "mixed farms" where the rise begins at about 130 acres after a quite steep decline from the peak at 230 acres, and is cut off at 77 acres. All the figures quoted above are taken originally from data gathered by the Farm Management Survey conducted by the Ministry of Agriculture, Food and Fisheries.

The implication of the figures given by Britton and Hill is that as farming is made more "efficient" in terms of its use of labour and capital it will produce less food.

Britton and Hill also acknowledge that the pursuit of agricultural efficiency may not be beneficial to the long-term maintenance of soil fertility and may therefore be directly contributing to a reduction of yields in the future - "A comparison of output/input ratios assumes that within each size-group of farms, operators would benefit from raising that ratio to a maximum and are aiming to do so, given the constraints on organisational possibilities imposed by 'fixed' resources. However, not all operators pursue this goal, at least in terms of the monetary values of output receipts and input expenses. They may follow an indeterminate but equally tenable concept of 'good husbandry' which would involve conserving the long-term production capacity of the land and establishing a pattern of resource use which would not place undue reliance on the continuing availability of 'external' supplies". This passage contains three important implied comments on modern farming; first, that it is not 'good husbandry'; second, that the pursuit of financial efficiency reduces the long-term production capacity of the land; and third, that it places "undue reliance on the continuing availability of 'external' supplies".

Increasing Food Production

In the year 1975-1976 the U.K. produced 53.7% of the food consumed here (including fish) and this represented 65% of the temperate climate foodstuffs consumed, the rest being items that cannot grow in the U.K. and must be imported. (Edwards 1977). During the same period, imports of food that could have been grown here cost £2103 x 10^6. If it is considered important for the U.K. to produce a greater proportion of its own food, then it seems that conventional 'agribusiness' is unlikely to be able to increase food production without decreasing its "efficiency", and this is unlikely to happen under the present organisation of agriculture.

Posner (1976), on the other hand, compares modern 'efficient' agriculture with the farming techniques practised by smallholders or peasant farms and comments ...... "there is hardly a sector where the yield obtained by the smallholder is not higher than that achieved on the large-scale farm. Small farmers are highly skilled craftsmen. They maintain and repair their means of production. They recycle animal and vegetable wastes and work hours not tolerated in any industrial plant. This intensive form of farming is the backbone of agricultural production in every Western country". Posner says that the need to produce more food will come to the Western countries "when Third World countries will make the necessary change away from plantation economies, and the exploitation of landless agricultural workers, we will find that we no longer have the knowledge, the adaptability of resources or means to produce our own food." He says that there is an "urgent need" for an agriculture based on "intensive cultivation and cooperation." It would appear then that an agriculture based on the techniques of smallholding might have possibilities for increasing food production.

An Existing Smallholding

Rather than making a purely theoretical study of smallholding it is proposed to look at an existing holding which is being used to gain experience in the appropriate techniques. It is not intended in this paper to go into the growing of domestic vegetables and fruit in any detail, as this has been thoroughly covered by such authorities as Hills (1971) and the Henry Doubleday Research Association. The work of these and others such as Hyams (1975) suggest that domestic vegetable requirements for four people can be adequately met from a plot of about 250 m^2. This is the area of the standard municipal allotment garden of 10 rods (300 square yards).

The holding to be studied has a clay soil overlying chalk and flint, and is situated on the edge of the ridge which forms the western end of the Isle of Ely in Cambridgeshire. It is about 20 metres above the surrounding fenland. The holding has an area of about 0.7 Ha (1.75 acres) and is a narrow plot with the long axis running North-South and the house at the extreme North end. The land is classified as Grade 1, which Mellanby (1975) defines as "land with very minor or no physical limitations to agricultural use. Yields consistently high - cropping highly flexible - most crops can be grown." The land is divided into an area of permanent pasture of $4350m^2$ an area of "arable" land of $1000m^2$ a vegetable plot, and about $400m^2$ of fruit trees. The rest of the land is occupied by hedges, paths, buildings and a lawn.

At present the holding provides all the vegetables and most of the fruit for two adults and a child, with surpluses being frozen or bottled for winter use, or given away. Experience of livestock management is being acquired by the keeping of a cow, hens, ducks, a sheep and bees, with a pig kept during the winter for fattening.

The cow (a Jersey) has grazing on site for half a year, with bought-in hay and concentrates for the winter, total cost including straw for bedding being £75 for the winter of 1976-1977, or about 40p per day for an average of 4.5 litres of milk (8 pints) daily over the winter. Improved management of the summer grazing allowed 1880 m^2 to be cut for hay in the summer of 1977, yielding about a ton. The cow is inseminated yearly to produce a Jersey/Angus cross calf, the aim of the Angus being to increase the beef quality of the calf without making it too large to be born easily. Up to the end of 1977 the cow has had four calves (all heifers) and has required no assistance of any sort at calving. The most recent calf was killed at four months old and yielded 68 kg of boned meat. Its food consisted entirely of milk and grass, as it was allowed to run with the cow on grass, and suck at will.

The poultry are fed on wheat and blood and bone meal, as advocated by Worthington (1970) and Singer 1976). The meal is made from slaughterhouse wastes and is fed in small quantities to provide protein. It and the wheat, which is easten at the rate of 40 kg per bird per year, have to be bought in. Having been kept on free range, which was unsatisfactory because the field was not securely fenced and the birds went frequently into a neighbouring garden, and in a fenced run which became very muddy in winter and allowed no access to green food, the poultry are at present kept in a movable fold unit. This is moved onto fresh grass each day, giving the birds fresh green food which Worthington considers essential, and allowing the droppings to fall onto the grass to encourage its growth.

The sheep was bought in the spring of 1977 as a lamb, and will be mated in the autumn to produce a lamb in Spring 1978. It is tethered on the lawn or on other parts of the site where grass is available, and receives no other food in the summer, but has hay and some bought in concentrates in the winter.

A pig is bought in the winter and fattened to bacon weight on bought in barley meal, surplus skimmed milk from butter making, and surplus vegetables, peelings and weeds. The total cost of the pig kept in the early part of 1977 was £40 to produce 50 kg of boned meat (110 lb); this is the money paid out for the pig itself and for the barley meal, the labour, weeds and skimmed milk are not costed as they are produced within the holding.

Types of Diet

Before examining ways of planning the cropping of the smallholding, the question of type of diet must be discussed. It is often stated that a vegetarian diet would be preferable, since apart from any moral arguments about killing animals for meat, more food can be produced per hectare by growing crops for human consumption than by feeding the crops to animals which are then eaten (see for example Lappe, 1975; and Joyce 1976). This fact of increased food availability from a vegetarian diet is indisputable, but must be set against the fact that the national per capita consumption of all types of meat in 1973 was about 65 kg (Mellanby, 1975). This suggests that a proposal for food production based on vegetarianism would be unlikely to find much support among the majority of the population. At the same time, if the vegetarian diet is to inclue milk, cheese and eggs, there will be bull calves and cockerels produced each year, as well as heifers and pullets. If these are killed at birth, since they cannot be kept to grow to old age naturally because they would eat too much, the moral argument against killing them for meat no longer holds. In that case, it is probably better that these animals should be fattened to a reasonable size before being killed, as there is little meat on a new-born calf and none at all on a day old chick. If they are killed at birth to avoid extra food being used to fatten them, their carcases are largely wasted. The alternative to the lacto-vegetarian diet described above is the Vegan philosophy in which no animal products are eaten or used in any other way (for example no leather is used). In the UK, assuming that the aim was to produce food to reduce imports, a Vegan diet would tend to be very limited, as many of the usual ingredients, such as soya beans, chick peas, various nuts, olives and other crops cannot be grown in the UK.

Even assuming that Vegans could propose an attractive and nutritionally sound diet based only on UK produce, their remains one reason for retaining livestock in agriculture which is more important than diet, and that is because of their manure. Such diverse authorities as Seymour and Seymour (1973) and Henderson (1944) stress the point that the fertility of land can be greatly increased by high rates of stocking with a wide variety of animals. The high stocking rate means that large quantities of manure are deposited on the land. This acts as fertiliser and helps to improve soil structure by tending to increase the humus content. This point is explained in great detail by Howard (1940) and Balfour (1975).

Yields and Cropping Plans

The calculation of cropping plans for smallholdings, particularly for one as small as 0.7 Ha, is not an easy task since figures of yields are not readily available. Yields or garden produce have been measured by the Henry Doubleday Research Association (see, for instance, Hills, undated) and these may be appropriate for a holding which is really only a large garden. In the study made by Best and Ward (1956) of the effect of building houses at a density of 20 per Ha on agricultural land, it was shown that this would yield more value (in money terms) of food from gardens than the farmland. This suggests that small areas of crops yield more than large areas of the same crop, but part of the increase in value of output may be due to the fact that gardeners may raise things like early peas, new potatoes and other "luxury" items, which are not economic on a farm scale.

In the following discussion, any benefit that might arise if, as is sometimes suggested, yields from small areas are greater than those from a large area of the same crop is ignored. This factor is due to the attention that can be given by the small-holder at an individual plant level to the small area as mentioned by Hyams and Posner. Yield figures in the following discussions of cropping are taken from Halnan and Garner (1953) and have been confirmed by the Ministry of Agriculture, Fisheries and Food (1960). These are figures for large scale agricultural crops and, in the case of Halnan and Garner, wiriting in 1953, are prior to the widespread intensive use of artificial fertilisers, pesticides and herbicides (Allaby, et al 1974) and are therefore likely to be applicable to a smallholding where external inputs to maintain fertility and control pests are being avoided where possible. Halnan and Garner describe the yields quoted as "good average figures".

Hymans (1975) quotes a table prepared by Professor Dudley Stamp in 1948 comparing garden and farm yields for various crops. The farmer produced 2.1 tons per acre (5.25 T per Ha) more beetroot than the gardener and 1 ton per acre (5.25 T per Ha) more cabbage, but the yields of other crops were either more or less equal or showed a clear advantage to the gardener, the gardener getting an average of 7.1 tons per acre (17.75 T per Ha) to the farmer's 6.3 tons per acre (15.75 T per Ha). None of these sources deals with the growing of stictly agricultural crops on a garden scale. Seymour (1976) is the only contemporary UK writer on small-scale farming, and he says very little on the subject of yields.

Cropping for Livestock

Whatever the system of farming, the basic nutritional requirements of livestock do not change, what does change is the type of food used. As present agricultural practice in the UK requires that labour costs be minimised, there is little information concerning ways of feeding livestock for maximum production off home produced foodstuffs. All such techniques demand more expense for labour than the cost of compounded feedstuffs in prepared form, which are very simple to feed and balanced for the requirements of intensively housed livestock (pig pellets, layers' mash, etc). The emphasis is on techniques of housing and feeding to minimise labour and maximise profit. On a smallholding the emphasis is on the production of as much food as possible, with labour being a less important consideration; if the smaallholding is small in area, the hours worked on it are likely to be less than on a large farm, but the input of labour per hectare will be far greater.

Cropping for Cows

Before livestock rations can be worked out and a cropping plan suggested, the amounts of food required by different animals must be found. The requirements of ruminants (except goats) are given by the Ministry of Agriculture, Fisheries and Food (MAFF) in Technical Bulletin 33 (1975). The requirements for cows show that an average Jersey cow of 350 kg liveweight giving 10 kg of milk per day (this is slightly more than 2 gallons, a gallon of milk weighs about 4.5 kg) needs food with an energy content of 102 MJ per day (28 KWh). The Jersey is chosen because at lowish yields (up to 15 kg per day) it will give more milk per MJ than any of the larger breeds; a further advantage is that low yielding cows are less likely to suffer from 'production diseases' caused by feeding for high milk yields (Barron, 1972 and Cochrane 1946) and need less concentrates to produce milk; for example, Russell (1954) gives a ration for 9 kg of milk a day from a 560 kg cow consisting solely of hay and grass silage. The high butterfat content of Jersey milk, 48 grams per kg compared with 34 grams per kg for Friesian milk (MAFF 1975) makes the production of butter simple. Being small and docile the jersey is an ideal "house cow" for the smallholder, a view confirmed by Seymour (1975).

Some authors (Mellanby, 1975; Henderson 1950) say that it is possible to keep a cow on 0.4 Ha (one acre), and Henderson goes into the details of cropping to achieve this. It is worth noting that Henderson was a practising farmer, and relied on no artificial fertilisers, using high stocking rates to build up and maintain the fertility of his land. His suggested cropping on one acre (4047 m^2) is as follows:

1350 m^2	grazing in summer, managed by tethering
1350 m^2	cut for hay, then grazed
1000 m^2	oats and peas, undersown with trefoil for late grazing
350 m^2	kale and mangolds "on which turnips were broadcast just before the row closed, and provided extra keep when the main crop was removed."

Taking the 200 day winter feeding period advocated by Russell (1954) to allow for unfavourable spring weather, and using the yields given by Halnan and Garner, MAFF (1960), and Hurst (undated) and the energy contents of feeding stuffs given in MAFF (1975) it is possible to work out the energy given by the winter portion of Henderson's ration. Since Henderson refer to the use of "intensively farmed land" to support one cow to the acre, where the yields have been given by the sources listed above as a range (i.e. 20-30 tons per acre) the higher figure has been used. On this basis Henderson's cropping plan could produce 92 MJ per day for 200 days or 102 MJ for 180 days. Table 1 of the Appendix sets out the yields etc., used to arrive at these figures. The ration provides 9.25 kg DM daily compared with a probable dry matter appetite limit for a 350 kg cow, yielding 10 kg of milk a day, of 9.8 kg DM (MAFF 1975).

Turning to summer feeding, Henderson proposes an area of pasture followed by the aftermath of hay and the trefoil sown under the oats and peas. MAFF (1967) suggests that 2023 m^2 (half an acre) will, with adequate fertiliser application, provide grazing for a cow from April to September if a rotational system is used. This means that the cow is given a small area of grass, sufficient for a day's grazing, and is then moved so that each piece of grazing is eaten down and then rested for twenty-one days. On the 2023 m^2 this represents 96 m^2 per cow per day. Since this reference is from a leaflet for dairy farmers, it is likely that the cows it discusses will be Friesians yielding about 20 kg per day. Russell (1954), Cochrane (1946) and MAFF (1960) state that grass alone can supply 20 kg of milk and maintenance for a Friesian for a good part of the summer, which suggests that 96 m^2 of grass can supply the 161 MJ which a Friesian yielding 20 kg will need daily (MAFF 1975). Under Henderson's plan the cow will have 64 m^2 of grazing daily until the aftermath of the hay can be used in late July or early August, and on a simple proportional basis (i.e. if 96 m^2 can supply 161 MJ) this area represents 107 MJ per day.

It can be seen that Henderson's proposal, which is mentioned in passing in his book as a way of getting 2700 kg (600 gallons) of milk annually from an acre of land, seems to supply the correct energy level for this production from a Jersey cow, assuming a sixty day dry period before calving. This level of production needs high crop yields to sustain it, but it is worth noting that a Jersey needs only 41 MJ per day for maintenance, (MAFF 1975) and could therefore be kept alive through the winter even if crop yields were 60% lower than expected.

Henderson's cropping system is not the only way of feeding a cow off an acre of land. Wibberley (1916) writes "one acre of land properly cropped with forage crops will provide enough green food to feed at least three cows throughout the summer", and goes on to describe his "continuous cropping" system which he claims can be worked on 20 acres (8 Ha) by a man and a boy for manual work plus "a woman to help in the dairy" and two strong cobs (horses) to do the cultivations. One advantage claimed for his system is that it allows cultivations to be carried out in the drier parts of the year, whereas the traditional Norfolk rotation requires almost all ploughing and preparation of land to be carried out during the wettest months. This is not a great problem in dry areas such as East Anglia, but can cause difficulties in more westerly counties. Wibberley's suggested cropping is as follows:

Year 1	tares for soiling (tares are a mixture of cereals and vetches; soiling is the cutting of a crop for feeding to housed livestock, now called "zero-grazing')
Year 2	tares for hay followed by winter forage crops.
Year 3	roots (mangolds and potatoes)
Year 4	tares for hay with seeds (rye grass and clover)
Year 5	seeds for soiling.

It should be noted that in four years out of five, one of the crops grown is a legume, and will therefore fix nitrogen from the air to benefit following or accompanying crops. On an acre this system would use five plots each of 800 m^2, and would give 1600 m^2 of soiling crops for summer use. This is greater than Henderson's original allowance for grazing (1350 m^2) but Henderson's plan allows for grazing of the hay aftermath to give extra grass late in the summer. Wibberley's plan requires that one plot of tares be ploughed immediately after cutting hay so that "winter greens" can be planted, but the tare and seeds hay plot could provide some late season grazing before being shut up for the winter. Wibberley says that each acre of soiling crops should provide 20 tons of food, and that a cow will eat 112 lb (50 kg) per day, so that in a 160 day summer (May 1 to October 7) the cow will eat 8 tons, on the produce off 2/5 acre (1600 m^2). When worked out, using the yields given for each crop by Wibberley, the winter part of the proposed cropping would yield 136 MJ per day for 210 days (See Table 2 of the Appendix for details), which would give 15 kg of milk per day from a suitable Jersey cow (MAFF 1975). The ration would vary somewhat during the winter, as the kale could not be sown until after the tare hay had been cut in June, and would not be ready for feeding until December, or even as late as February. This would mean that roots would be fed until the kale was ready, and the ration would then change over to kale. However, mangolds are not safe to feed until January (Cade 1977; Halnan and Garner 1953), because of their amide content, so if the potatoes were not deemed sufficient, some kale could be sown in a seed bed and transplanted when space becomes available, to allow kale to be used throughout the winter. It would be possible to use an electric fence, not available when Wibberley was writing, to avoid having to cut and carry the soiling crops to the cow. The fence could be used to fold the cow over a day's portion, and moved each day to provide fresh food.

In conclusion, it is interesting that there are at least two fully documented cropping plans for feeding a cow entirely off one acre. Wibberley's system is modified in his book, according to regional climatic differences, and is therefore applicable in principle over the whole of the UK if his recommended regional cropping plans are followed. It is important to note that Henderson's and Wibberley's proposed cropping plans are entirely practical in that they provide the correct energy level to feed a cow, although the Metalisable Energy system (MAFF 1975) of checking a proposed diet for a cow had not been devised when they were writing.

Cropping for Hens

During war time, the production of as much food as possible from the land available increases in importance as imports may be prevented by the war. Halnan and Garner (1953) discuss the feeding of livestock in wartime to make maximum use of home produced foods, and they suggest that when this is the aim, poultry should be kept on free range, rather than intensively to take advantage of the fact that the birds will obtain 10%-15% of their food requirements from grassland. MAFF (1974) states that "good range" (i.e. grass) can provide up to 20% of the food needed from four weeks old, but it is not made clear whether this refers to fowls or ducks. Halnan and Garner add that poultry can be stocked on grassland at the rate of 50 to the acre (125 to the Ha) without affecting the value of the land for other livestock. Henderson (1944) emphasises the benefit of poultry on grassland and says "so highly do we value poultry for fertility purposes that we would consider their retention justified even if they did not leave a profit in their produce."

Most of the literature on poultry (Singer 1976; Worthington 1970; MAFF 1974) stresses the importance of cereals, especially wheat, with a recommended daily intake of about 110 grams per bird on a grain-only feeding system. This gives an annual grain consumption of about 40 kg per head, which with a wheat yield of 1.5 tons per acre (3.7 T per Ha) will require an area of about 100 m^2 per bird per year for the grain ration. (Halnan and Garner also recommend the use of sunflower seeds as a substitute for wheat for poultry, but give no figures to allow the yield to be compared with that of wheat). Thomas (1976) gives a figure of 181 m^2 per bird for intensive layers on a diet of grains and beans, but this seems slightly excessive. On an intensive smallholding it is important to try to find a diet that will provide more poultry food from a given area, without giving the birds an excess of cellulose which they cannot digest. Robinson (1951) gives a diet for laying hens used at the National Poultry Institute, Wye, Kent, by Halnan and Fermor in 1942, and made up as follows:

80 lb	(36 kg)	potatoes
20 lb	(9 kg)	middlings
3 lb	(1.36 kg)	white fish meal
3 oz	(85 g)	common salt.

The potatoes should not be peeled and should be boiled or steamed for half an hour or simmered for 1-1½ hours to improve the digestibility of their starch content (MAFF 1968b). Middlings is a by-product of the flour-milling industry, it is formed of the second layer of the grain and should contain much of the wheat germ. The fish meal and salt is necessary to balance the ration. Because of the high starch content, the birds will eat 10-12 oz (280-340 g) per day or about 120 kg per head per year. Assuming that wheat is used in place of middlings, the annual requirements will be roughly 90 kg potatoes, 20 kg wheat and 3.5 kg fish meal.

Henderson (1950), describing his own wartime poultry diet, gives daily consumption figures of 110 grams potatoes, 28 grams meal (about 20% protein) and 57 grams grain "as a minimum to keep a bird in full production". It is evident from Henderson's earlier writing (1944) that "meal" is used here in the sense of a cereal or similar product, finely ground, rather than a high protein substance such as fish meal. This gives an annual consumption per bird of 40 kg potatoes, 21 kg of grain and 10 kg of meal.

To calculate the area required to grow potatoes for poultry causes a slight problem, as the figure given above of 90 kg per bird per year is of cooked potatoes, and it may be that the potatoes absorb water during the cooking process, but assuming that the 90 kg figure is correct, and taking the yield figure from Hills (undated) of 4.3 kg potatoes m^2 (this is about 17 tons per acre or 50 T per Ha), then each bird will require the potatoes from 21 m^2 of land. Hills' figure is thought to be applicable here as it is a garden yield, and an intensive smallholding is cropped on a garden rather than farm scale. If a more conventional farm yield is assumed, the area needed would be increased to about 30 m^2 per bird.

If potatoes are used as part of the diet, the area of land needed to feed a hen for a year is reduced from about 100 m^2 on an all-grain diet, to between 70 m^2 and 80 m^2, with the added advantage on a smallholding that the diet is composed of two different categories of crops, grains and roots, and can be fitted more easily into a rotation. For example, on an all-grain diet, ten hens need 10 x 100 = 1000 m^2 of wheat, wheat, which means in a four course rotation, a total area of 4000 m^2; whereas on the grain and potato diet ten hens need 10 x 50 = 500 m^2 of wheat, and perhaps 10 x 25 = 250 m^2 of potatoes, but with a four course rotation, the total area for cropping is only 2000 m^2 because the wheat and potatoes are two of the four courses, meaning that twice as many hens can be fed from the same area of smallholding. This, of course, only holds true when rotation is being practised rather than continuous growing of the same crop, and where the rotation includes only one cereal "break".

Cropping for Pigs

Cobbett in Cottage Economy says that bacon must be "the effect of barley or peas (not beans), and not of whey, potatoes, or messes of any kind" but, in spite of this, most writers on the feeding of pigs stress the usefulness of potatoes, particularly steamed or boiled, in the feeding of pigs. Reid (1955) and Williams (1977) discuss the Lehmann system evolved in Germany as the most satisfactory way of feeding large quantities of potatoes. Under this system the pig receives meal only until it is consuming 1 kg daily (i.e. at about twelve to fourteen weeks old). When this level of consumption is reached, steamed potatoes or other bulky foods are fed in gradually increasing quantity to satisfy the pig's appetite. The meal used should be about 80% cereals and 20% protein concentrates.

Tinley (1947) quotes Fishwick of Wye College, who states that a sow rearing two litters per year, each of eight pigs, will consume in a year 1110 kg of meal on an all-meal feeding system. Williams says 1500 kg. If this consumption, using Fishwick's figure, is worked out per weaned pigling, each will have required about 70 kg for its production on an all-meal system. On the Lehmann system which is equally suitable for breeding stock, as well as fattening, the sow will have 365 kg per year of meal, with the remaining 745 kg of meal replaced by steamed potatoes. Halnan and Garner (1953) state that 3.4 kg of cooked potatoes are equivalent to 1 kg of barley meal, which means that the sow will need 2533 kg of potatoes per year or roughly 7 kg per day. In fact, daily consumption will vary depending whether the sow is pregnant, lactating or resting. On this basis each pigling up to weaning age will account for only 23 kg of meal and 158 kg of potatoes eaten by the sow.

According to both Halnan and Garner and Fishwick (quoted by Tinley), a pig reared to bacon weight (90 kg) will consume 300 kg of meal on an all-meal diet. Using the table of ages, weights and food consumptions, given by Tinley, it can be shown that a baconer will eat about 20 kg of meal from weaning until it reaches a daily consumption of 1 kg when it is eleven weeks old. From then until it reaches 90 kg weight at twenty-nine weeks old, it will eat, under the Lehmann system, a total of 126 kg of meal and about 600 kg of potatoes. The pig will produce about 60 kg of carcase (Halnan and Garner) or 45 kg of usable meat for bacon. To grow the 150 kg of meal eaten by the pig, from weaning to slaughter, assuming it is all barley meal and that the yield of barley is 1.5 tons per acre (3.7 T Ha), will need about 400 m^2, with a further 60 m^2 to supply the meal that was needed by the sow to produce the weaner. The potatoes to fatten the weaner will, with a yield of 12 tons per acre (30 T Ha), take an area of 200 m^2 with a further 50 m^2 to allow for the production of the weaner.

In conclusion, it can be shown that to fatten a weaner pig to bacon weight requires about 600 m^2 of land, and a further 110 m^2 to produce the weaner on a Lehmann system diet. The last figure is more accurately put at 1760 m^2 to keep a sow to produce sixteen weaned piglings per year. On a meal only diet, each pig from weaning to bacon would need the barley from 810 m^2 plus a further 190 m^2 to produce the weaner. The Lehmann system reduces the area needed to produce each pig by 30%.

Cropping for Sheep

MAFF (1975) gives energy allowances for sheep, which for lowland ewes of between 60 kg and 70 kg liveweight, show a maximum energy demand of 30 MJ per day in the first month of lactation (assuming twin lambs) and a maintenance demand of 9 MJ per day when the sheep is neither in lamb nor lactating. The gestation period of the sheep is twenty-one weeks, but the maintenance energy level is sufficient until the sixth week before lambing, when it should rise to roughly 10 MJ per day (for a 60 kg - 70 kg lowland ewe expecting twin lambs), reaching a maximum of 16 MJ per day in the last week of pregnancy. The lactation period then lasts a further ninety days, during which the sheep should receive 30 MJ per day in the first month, reducing to 20 MJ per day in the last month of lactation.

Grass will be available from May until October and will have to provide 20 - 25 MJ at the beginning of the season, falling to 9 MJ per day from June to October. Following the example of the cow rations in the earlier part of this Paper, it can be seen that grass can provide at least 1 MJ per m^2 per day, so the sheep and lambs will need 20 m^2 per day in May. The lambs, when weaned, will need 2.9 MJ per day when they weigh 10 kg and 8.9 MJ when they weigh 50 kg each, at which point (if not before) they would be eaten. It should be noted that all these calculations assume that the sheep has twin lambs.

The sheep's energy requirement drops once the lambs are weaned, so the average requirement would be 6 MJ per lamb and 9 MJ for the sheep - a total area of grass of 21 m^2 per day, or 440 m^2 on a twenty-one day rotation like that described for the cow. The sheep could follow the cow on its rotation, with a slightly increased area per day. If there is a shortage of grass, the lambs could be eaten as 'fat lambs' at twelve to fourteen weeks old, in July, rather than being fattened to mutton weight in the autumn (Henderson 1944).

Henderson (1950) describes his winter feeding of sheep as follows:

> "Up to Christmas they get nothing but grazing on grass, stubble and perhaps clearing up of kale after cattle; from the New Year, one mangel a day until lambing, when it is increased to two. No hay is fed before lambing, except in a period of extreme frost, and it never exceeds 1 lb per head per day."

From the energy requirements, it appears that the critical time for winter feeding (assuming the sheep lambs in March) is during March and April, when a sheep with twin lambs will need 30 MJ per day in March and 25 MJ per day in April, a total of 1680 MJ to be provided by winter feeding stuffs during these two months. The total requirement to feed the sheep over the notional winter period from October to April, allowing for pregnancy and lactation, is 3330 MJ. The animal will need only 9 MJ per day until December, and it seems reasonable to suppose that this could come from grazing, provided that the land is not likely to become too muddy from treading. Seymour (1976) says that

> "Sheep are very good for grass in the winter time - they 'clean it up' after cows have been grazing on it all summer, because they graze much closer than cows."

He adds that they need hay in winter only in "very cold climates". This leaves 2500 MJ to be provided from stored foodstuffs. Following Henderson's recommendation, if 0.5 kg of hay is fed per day from the beginning of January until the end of the winter (it is probably desirable to feed some hay, Halnan and Garner recommend 0.25 kg daily and a maximum of 7 kg of roots during early pregnancy) the sheep will require 60 kg of hay, the produce of 100 m^2, which will give 430 MJ if it is hay of average quality. The remaining 2070 MJ could be provided by 1175 kg of kale, grown on 160 m^2, or by 1280 kg of mangolds, grown on 100 m^2.

In conclusion, a single lowland ewe will need a maximum of 260 m^2 for her winter keep, and could be fed off 200 m^2, both figures assuming that suitable grazing was available for use until Christmas. The sheep will need a further 440 m^2 of grazing in in the summer, which makes a total of no more than 700 m^2 of good land to feed a sheep to produce a fleece and two 50 kg lambs per year.

Cropping for an existing Holding

To provide a more practical example of the possibilities of a smallholding, it is proposed to apply the above information on animal feeding to the 0.7 Ha smallholding described earlier in this paper. This will allow stocking rates per hectare to be assessed, with an allowance automatically made for buildings, hedges, gardens, and other non-agricultural uses of the land. It is assumed that the existing arrangement of 'arable' plots and grazing is used, with the addition of 1000 m^2 of arable land taken from the existing grazing area, leaving 3350 m^2 of grazing. The arable would be divided into four plots, each of 500 m^2, and the following rotation might be used:

Year 1	Potatoes followed by winter wheat.
Year 2	Tares (also called vetch) planted after wheat is harvested, for grazing off in spring.
Year 3	Kale
Year 4	Sugar beet followed by tares (as above).

Tares are used rather than any of the commoner 'catch crops' because almost all of these (stubble, turnips, rape, etc.) are brassicas, like kale, and plants of this family are best grown only once in a rotation because of the club root danger (Hills 1971). Tares also have the advantage that, in being legumes, they add nitrogen to the soil. This rotation will grow the following crops:

Potatoes	500 m^2
Wheat	500 m^2
Kale	500 m^2
Sugar Beet	500 m^2

as well as

Tares (for winter grazing)	1000 m^2

Using the figures for yields from the earlier examples, gives yields as follows (Note - these are yields as harvested, not dry matter yields):

Potatoes	1500 kg	(12 tons per acre)
Wheat	185 kg	(1.5 tons per acre figure from Halnan and Garner 1953)
Kale	3700 kg	(30 tons per acre)
Sugar Beet	2300 kg	(18.6 tons per acre)*
Sugar Beet Tops	1100 kg	(8.9 tons per acre)*

* The figures for sugar beet and beet tops are taken from Danish averages quoted by Halnan and Garner, which show that sugar beet has the highest dry matter yield per acre of any roots. MAFF (1975) shows that sugar beet also have the highest metalisable energy content (13.7 MJ/kg DM) of all the root crops.

The grazing area, 3350 m^2 would be used also for hay; on Henderson's tethering plant, the cow would have 64 m^2 per day on a twenty-one day rotation in the earlier part of the summer, a total of 1350 m^2, leaving 2000 m^2 to be cut for hay, which should provide at least 1000 kg, and possibly as much as 1200 kg (using Halnan and Garner's yield figure).

From the earlier section of this paper, it was shown that a weaner pig fattened to bacon weight, would eat 300 kg of potatoes and 150 kg of meal. On the smallholding, the meal would have to be bought in. From the total grown, this would leave 900 kg of potatoes, of which 450 kg would be eaten by five hens, and 500 kg by four people (average consumption 97 kg per head in 1973, Mellanby 1975). The hens would also eat 100 kg of wheat, leaving 85 kg for other uses. The sheep will need 60 kg of hay and 1200 kg (approx.) of kale, although these amounts could be significantly reduced by grazing from the autumn sown tares crop.

The feeding of the livestock listed above leaves 940 kg of hay, 2500 kg of kale, 2300 kg of sugar beet and 1100 kg of sugar beet tops available to feed the cow through the winter. This amounts to 20500 MJ, or 102.5 MJ per day over two hundred days. The cow's calf will have had milk and grass over the summer, and could have a little hay from the cow's ration, but the better policy is to kill the calf at the end of the summer (assuming the cow calves in the spring) when it will be about siz months old and will give at least 60 - 70 kg of usable meat if it is a Jersey or Jersey cross. If it is assumed that the calf has, on average, 5 kg of milk per day through its life, the cow's annual yield will be reduced to 2250 kg.

It should be added that the orchards and vegetable plot on the smallholding could probably provide enough food to fatten a goose and to support a few rabbits kept for meat, but these will not be included in the final calculation of cropping.

The Implications

Land

Mellanby (1975) estimates that there are about 22×10^6 acres 8.9×10^6 Ha) of land in England, Wales and Scotland that could be used to grow arable crops - this is the land classified as Grades 1, 2 and 3 in the MAFF Land Classification categories.

Cereals and Sugar

Using Mellanby's figures for annual food consumption per head of population, and assuming a population of fifty-five million, it is possible to work out the total amounts of various foods that must be grown for human consumption. Mellanby also gives the acreages and total yields of the various crops so that the areas of land needed to grow the different foods can be worked out as follows:

TABLE II

Food	Annual Consumption per head	Total amount	Area of land required
Wheat	64 kg	3.5×10^6 Tonnes	0.8×10^6 Ha
Barley	20 kg*	1.1×10^6 Tonnes	0.28×10^6 Ha
Oats	10 kg+	$.55 \times 10^6$ Tonnes	0.14×10^6 Ha
Sugar	48 kg	2.6×10^6 Tonnes	0.46×10^6 Ha
		Total:	1.68×10^6 Ha

* This is barley used for brewing, no other barley is eaten by people.

+ Mellanby gives no figure for oats, so half the total production in 1973 has been assumed to be used for human consumption.

Vegetables

As stated earlier in this paper, the vegetables for four people can be grown on a standard 250 m^2 allotment garden, which means that the vegetables for fifty-five million people will need an area of 0.34×10^6 Ha, or perhaps 0.4×10^6 Ha, to allow for paths, hedges, etc. The total land used to grow the existing cereal crops, sugar and vegetables is therefore about 2.1×10^6 Ha. This leaves 6.8×10^6 Ha of the first, second and third grade land to produce the other food, particularly meat and dairy products.

Animal products

Using the 0.7 Ha smallholding as an example, food production rates are as follows:

TABLE III

Product	on 0.7 Ha	on 1 Ha
Milk	2250 kg	3210 kg
Lamb and Mutton	32.5 kg*	46 kg
Pig meat	46.6 kg+	67 kg
Beef	65 kg	93 kg
Eggs	1000 no.	1430 no

* This figure assumes each sheep has 1.5 lambs.

+ This figure allows for the fact that the pig on 9.7 Ha needs a further 510 m^2 to produce it as a weaner and to provide its barley meal.

Dairy Products, Meat and Eggs

Returning to Mellanby's figures, the annual consumption of cheese is 0.32×10^{6} Tonnes. Davis (1965) gives figures of 0.9 lb to 1.5 lb of cheese, depending on type from 1 gallon of milk, while Tubbs (undated) says that 1 kg of cheese can be made from 7.4 kg of Jersey milk. For the purposes of simplicity, it will be assumed that 1 kg of cheese is made from 10 kg of whole milk, which means that the cheese will need 3200×10^{6} kg of milk for its production. Liquid milk consumption is given by Mellanby as 174 kg per head, which gives a total consumption of just under 9600×10^{6} kg. Milk consumption for cheese and as liquid is therefore 12.8×10^{9} kg. Given that 1 Ha can give 3210 kg (see above) this level of production will take 4×10^{6} Ha.

If all the cows are Jerseys, the milk could be partially skimmed to make butter without removing all the milk butterfat content. The partially skimmed milk would then be used in place of whole milk to supply the liquid milk demand. Singer (1976) quotes a yield of ½ oz of butter from 1 pint of milk if hand skimmed, or 1 kg butter from 40 kg milk. This would give a total butter production of $.24 \times 10^{6}$ Tonnes, which is over twice the home production of butter in 1973 ($.1 \times 10^{6}$ Tonnes).

If each cow is assumed to have a useful life of ten years (Cochran, 1946 says that there is no reason "why the average cow, given a chance, should not lead a profitable existence until she is ten years old") and a replacement takes two years to come into production (SAYFC 1968), the numbers of cattle must be increased by 20% from 5.69×10^{6} to 6.83×10^{6}, which will need 4.8×10^{6} Ha. The cows and heifers will each raise a calf annually, but 10% of the calves will be needed as replacements, so the production of beef will be 0.4×10^{6} Tonnes annually, assuming the calves are killed at six months old. The Jersey cows can be crossed with other breeds to produce better beef calves.

The land which is carrying the cows and calves will also support other livestock as described earlier, in the smallholding cropping plan, giving a total production from the 4.8×10^6 Ha as follows (1973 total consumption is also shown):

TABLE III

Product	1973 Consumption	Production off 4.8×10^6 Ha
Milk	9600.00×10^6 kg	9600.00×10^6 kg
Cheese	0.32×10^6 T	0.32×10^6 T
Butter	0.45×10^6 T	0.24×10^6 T
Eggs	13475.00×10^6 no.	686.00×10^6 no.
Lamb and mutton	0.40×10^6 T	0.22×10^6 T
Pig meat	1.50×10^6 T	0.32×10^6 T
Beef	1.1×10^6 T	0.40×10^6 T
Chicken	0.67×10^6 T	0.07×10^6 T *

* Assuming that hens are eaten after their first year of laying and give 2 kg of meat.

NOTE: The figures in the above table are partly from Mellanby directly and partly deduced from data given by him (for instance he gives per capita home production and imports of beef, pork and mutton combined and bacon separately and in another table total production of beef, mutton and lamb, and pig meat).

It can be seen from the above table that the production from the 4.8×10^6 Ha gives the following shortfalls on 1973 consumption:

Butter	0.21×10^6 Tonnes
Eggs	6615.00×10^6 no.
Lamb and mutton	0.20×10^6 Tonnes
Pig meat	1.18×10^6 Tonnes
Beef	0.60×10^6 Tonnes
Chicken	0.61×10^6 Tonnes

However, there are 2×10^6 Ha of the first, second and third grade land left after 4.8×10^6 Ha have been used to produce milk and the accompanying livestock as shown above. Taking the foods in order, it seems unlikely to be wise to try to produce more butter, the skimmed milk would be of little use, as milk demand for human consumption has already been met. It is worth noting that the butter produced from the 4.8×10^6 Ha (0.24×10^6 Tonnes) is more than double British butter production for 1973, and would therefore considerably reduce imports.

In the section describing the cropping of the 0.7 Ha smallholding, it was shown that a hen would need about 75 m^2 to produce all its food. This means that the shortfall of eggs could be met from 0.25×10^6 Ha, which would also yield another 0.07×10^6 Tonnes of poultry meat, reducing this shortfall very little. Robinson (1951) shows that to rear a chick to a liveweight of about 2.25 kg at twenty weeks (according to Robinson this will represent a yield of about 2.0 kg of 'chicken' meat) would take 11 kg of food. Halnan and Garner give a diet for rearing chicks similar to the potato based diet quoted earlier for layers. The layers consume roughly three times the quantity that they would eat on a grain diet, so it can be assumed that the chicks would do the same on the bulky potato diet, giving a food consumption of 33 kg per bird. This represents (at the recommended

80% : 20% ratio) 26 kg of potatoes, requiring 9 m^2 to grow them (Wibberley, 1916) and 7 kg wheat, requiring 19 m^2 (Halnan and Garner 1953) a total of 28 m^2 per 2.0 kg of meat. To grow the remaining 0.53 x 10^6 Tonnes of poultry meat required would therefore need 0.7 x 10^6 Ha.

The extra 1.18 x 10^6 Tonnes of pig meat required could be produced from 1.9 x 10^6 Ha, allowing for the production of weaners by the sow, and for fattening to a liveweight of 100 kg.

The extra pigs and poultry will need 2.85 x 10^6 Ha, but there is only 2.0 x 10^6 Ha of the better grade land available for use, so these meats may be slightly reduced in quantity, or it could be assumed that the best of the fourth grade land could be used to make up the difference.

The 0.2 x 10^6 shortfall in lamb and mutton could be largely, if not totally, made up from the 9.6 x 10^6 Ha of fourth and fifth grade land, as could some of the beef production if the right breeds were chosen, particularly if these poorer areas of upland grazing were improved as advocated by Stapledon (1943) to improve their stock carrying capacity. Blaxter (1975) estimates that the total area of rough grazing, which he puts at 6.6 x 10^6 Ha compared with Mellanby's figure of 6.9 x 10^6 Ha, can be estimated to be equivalent to 0.53 x 10^6 Ha of good agricultural land. Assuming that summer food only comes from grass, with all other food being grown in the form of roots and hay, a sheep needs about 700 m^2 per year if it is a lowland type and has two lambs. On this basis, the 'rough grazing' could produce at least 0.2 x 10^6 Tonnes of lamb and mutton per year, making up the shortfall in this area. This would still leave 2.8 x 10^6 Ha of grade four land, which is better land than the rough grazing available for other purposes.

Waste Products

It must be remembered that the crops grown for human consumption (corn, sugar beet, etc) will also yield usable feeding-stuffs from straw and other residues as follows (yields from Halnan and Garner):

Wheat straw	4 $\times 10^6$ Tonnes
Barley straw	1 $\times 10^6$ Tonnes
Oat straw	0.5 $\times 10^6$ Tonnes
Sugar beet tops	10 $\times 10^6$ Tonnes

The wheat straw, together with that from the wheat grown for feeding to poultry, which would give 4.6×10^6 Tonnes of straw from a total of 0.94×10^6 Ha, would be used for bedding of the cattle, pigs and other livestock. The remaining straws and the beet tops could be used to fatten some of the calves to a greater weight, or the beet tops could be fed to sheep as advocated by Halnan and Garner.

The straw and beet tops would have a total energy content, using data from MAFF (1975), of 10.74×10^9 MJ. If the calves are fattened from a liveweight of 150 kg, which is when they would normally have been killed, to a liveweight of 300 kg, and a gain of 1 kg per day is aimed for, each will need a total of 5150 MJ for a gain of 115 kg in edible meat compared with killing the calf at 150 kg liveweight (assuming a 60% killing out percentage on the finished animal, MAFF 1959). The waste materials will therefore give a further 0.24×10^6 Tonnes of beef, reducing the shortfall to 0.46×10^6 Tonnes.

Fruit

The calculations for livestock production suggest that 7.65×10^6 Ha will be required to be farmed as smallholdings to produce the amounts of dairy produce, eggs and meat consumed in 1973. However, as the yields from each smallholding are based on those for the 0.7 Ha holding described earlier, each 0.7 Ha will have 400 m^2 of soft fruit and orchard fruit, or 570 m^2 per Ha of smallholdings. This gives a total area for all types of fruit of 0.44×10^6 Ha compared with a present area of 0.075×10^6 Ha (Allaby et al 1974). Yields of fruit are not easily available, but MAFF (1964) gives yields of 4-5 tons per acre (10 - 12 T per Ha) for cider apples and MAFF (1972) gives 3-5 tons per acre (7-12 T per Ha) for gooseberries. Assuming that an average yield for all types of fruit is 10 Tonnes per Ha, the area available will yield 4.4×10^6 Tonnes of assorted fruit. According to Allaby et al (1974), U.K. consumption of fruit, including pulp, dried fruit and fruit juice, was equivalent to 3.1×10^6 Tonnes of fresh fruit. The smallholding system could therefore produce more than enough fruit for the U.K. although there would be no citrus fruit and probably other changes in types of fruit eaten.

The Import Position

Mellanby gives, at the beginning of his book, a table of food production per head for the U.K. in 1973, showing which foods were home produced and which were imported. If this is compared with the production of food described in this paper the differences can be seen:

Food	Consumption per capita	Home Produced 1973	Imports 1973	Small-holding production	Small holding imports
Meat	52.7 kg	32.0 kg	20.7 kg	46.5 kg	6.2 kg
Poultry Meat	12.2 kg	11.8 kg	0.4 kg	12.2 kg	-
Eggs	245 no.	240 no.	5 no.	245 no.	-
Milk	174.4 kg	174.4 kg	-	174.4 kg	-
Cheese	5.9 kg	3.2 kg	2.7 kg	5.9 kg	-
Butter	8.1 kg	1.8 kg	6.3 kg	4.4 kg	3.7 kg
Fats & Oils	17.1 kg	2.7 kg	14.4 kg	nil	17.1 kg
Sugar	47.7 kg	14.9 kg	32.8 kg	47.7 kg	-
Wheat Flour	63.9 kg	36.0 kg	27.9 kg	63.9 kg	-
Potatoes	96.8 kg	92.7 kg	4.1 kg	96.8 kg	-
Tea & Coffee	5.9 kg	nil	5.9 kg	nil	5.9 kg

NOTE: Mellanby's table does not cover fruit, but Allaby et al (1974) give a per capita consumption of 5.7 kg, and the smallholdings give a production of 89 kg per capita. Figures for fruit imports are not available.

In almost all areas covered by Mellanby's table, the smallholding system has either eliminated or reduced imports. The only areas where this is not true are the obvious one of tea and coffee, and the fats and oils. However, the original table did not say which of these were of vegetable origin (rapseed oil, sunflower oil, etc) and which of animal origin (lard, suet, etc), and the smallholding system would be likely to produce more animal fats than the current method, since it produces more 'home produced' meat.

It should be noted that the smallholding system also makes no use of imported animal feeding stuffs, whereas Mellanby explains that the 'home produced' animal products in his table rely heavily on imported foods such as grains and soya meal. The calculations for the stocking rates on the smallholding system, being based on a holding of only 0.7 Ha also allow for 24% of the land under consideration being occupied by houses, barns, hedges, orchards, vegetable plots and other non-agricultural land uses.

The calculations in this paper are, of necessity, relatively inaccurate because of the impossibility of knowing crop yields with any certainty in different years. In a 'good' year, the production of food might be increased, and in a 'bad' year, it would be necessary to import more food or eat less. However, the 1973 diet is probably not nutritionally necessary, and a return in a bad year to the kind of diet used during wartime rationing would give a measure of flexibility if imported food was not available or was too expensive.

Employment

It is clear that the smallholding system, whether based on very small farms sharing machinery and other facilities on a co-operative basis, or on much larger farms using many workers, would require more people to work on the land than at present. To calculate the number needed it is necessary to realise that the smallholding system contains at least four categories of farming.

a) Large scale arable farming for cereals and sugar beet.

b) Smallholdings with livestock.

c) Vegetable growing on an allotment scale.

d) Hill farming of sheep and some cattle.

Category a) Large scale - This would be little different from current farming methods and can be assumed to employ one person per 100 Ha.

Category b) Smallholdings - Taking Wibberley's figure mentioned earlier of 8 Ha managed by a man, a boy and two horses, it is reasonable to suppose than an individual could, using a tractor rather than horses, manage a 10 Ha smallholding.

Category c) Vegetables - Hyams (1975) estimates that three hundred and five hours per annum of labour is needed to manage a plot of 250 m^2 to produce the vegetables for four people, without using machinery. Shewell-Cooper (1967) says that "a first-class gardener could look after between three-quarters of an acre and an acre of vegetables" without mechanical aids, and that with a rotary cultivator or similar equipment, the gardener would have time to "do the flower garden as well". It can be assumed, then, that one person can grow 0.4 Ha of vegetables if mechanical equipment is available.

Category d) Hill Farms - Hill farms can probably be managed on the same basis as Category a) with one person per 100 Ha.

Putting these figures together gives the following employment.

TABLE V

Category	Area	Ha per person	No. of people employed
a) Arable	1.68×10^6 Ha	100	16,800
b) Smallholdings	7.65×10^6 Ha	10	765,000
c) Vegetables	0.4×10^6 Ha	0.4	1,000,000
d) Hill Farms	6.6×10^6 Ha	100	66,000
	16.33×10^6 Ha		1,847,800

Assuming that a total of two million people are employed in agriculture, this represents 8% of the 1972 U.K. workforce (H.M.S.O. 1973, quoted in Elliott 1975). Allaby (1976) gives the E.E.C. average for workers in agriculture as 7.8% of the total working population, with France employing 11.5% and Ireland 24.9%. In comparison with the European average, the percentage of the U.K. workforce employed in agriculture, forestry and fishing, is only 1.7%. The implementation of the smallholding system would not be creating a totally new form of society that had not been previously experienced, it would be bringing the U.K. roughly into line with the other E.E.C. countries, while providing employment and greatly reducing the money spent on imports of food for people and livestock.

Finally, it must be remembered that the smallholding system uses only 16.33×10^6 Ha out of a total of 19×10^6 Ha, leaving some land free for other agricultural activities or for forestry, which would provide further employment opportunities.

Conclusion

It appears that an agriculture based on the techniques of smallholding with its high stocking rates, intensive cultivation and avoidance of waste, would be more likely to be able to reduce food imports and provide a satisfactory diet than current agricultural practice which places the emphasis on efficiency rather than production.

A change to a smallholding-based form of agriculture would provide more employment without causing a serious drain on existing industrial employment, and would leave the U.K. with a proportionately smaller agricultural labour force than some of the other E.E.C. countries. The savings in imports would be at least £2,000 x 10^6 (and probably more because there would be no need to import livestock feeds). There seems to be enough evidence to suggest that the present trend towards larger farms should be actively discouraged, and a policy to increase agricultural employment should be started. In this way the U.K. could have a better chance of obtaining adequate food supplies and full employment.

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APPENDIX

Table 1

Calculation of energy content of winter feeding stuffs grown according to Henderson's cropping plant:

Crop	yield per acre	yield per m^2	area m^2	DM kg/kg	MJ/kg DM	yield DM	Total MJ
Hay	2.5 tons (a)	0.62 kg	1350	185	9.0	711 kg	6403
Oats	1.3 tons (a)	0.32 kg	500 +	.86	11.5	138 kg	1582
Oat straw	1.5 tons (a)	0.37 kg	500 +	.86	6.7	159 kg	1066
Peas	1.3 tons *	0.32 kg	500 +	.86	13.4	138 kg	1844
Pea straw	1.5 tons *	0.37 kg	500 +	.86	6.5	159 kg	1034
Kale	20-30 tons (a)	7.4 kg	175 +	.16	11.1	207 kg	2298
Turnips	15-20 tons (b)	4.9 kg	175 +	.09	11.2	77 kg	865
Mangolds	30-50 tons (b) (c) (d)	12.4 kg	175 +	.12	12.4	260 kg	3229
					Total	1849	18321 MJ

Sources of yield figures: (a) Halnan and Garner (1953) (b) Hurst (undated) (c) Seymour (1976) (d) MAFF (1968)

*The yield of peas could not be obtained, so has been taken as equal to Halnan and Garner's yield for beans. The yield for pea straw has been taken as 1.5 tons per acre rather than the 2 tons given for bean straw, as the pea plant has a thinner stem than beans and seems likely to yield less straw.

+The assumed area of the oats and peas grown together is taken as half the total area sown, but Wibberley (1941) writing of intercropping wheat with winter greens, says that providing the correct quantity of seed is shown the yield of wheat will not be reduced by the intercrop. In this case, the yield of oats and peas may be under-estimated. The same applies to the kale, mangolds and turnips.

APPENDIX

Table 2

Calculation of energy content of winter feeding stuffs grown according to Wibberley's cropping plan (1916):

Crop	yield per acre	yield per m^2	area m^2	DM kg/kg	MJ/kg DM	yield DM	Total MJ
Tares hay	3.5 tons	.86 kg	1600	.85	8.1	1170 kg	9474
Kale	25 tons	6.2 kg	800	.16	11.1	794 kg	8809
Mangolds	30 tons	7.4 kg	400	.12	12.4	355 kg	4404
Potatoes	12 tons	3.0 kg	400	.21	12.5	252 kg	3150
Seeds hay	2 tons	.49 kg	800	.85	8.4	333 kg	2799
					Total	2904 kg	28636 MJ

All yield figures are from Wibberley (1916).