Energy Conservation in Amish Agriculture

Amish farmers can cut energy use without reducing yields, but this cannot be achieved everywhere.

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The increasing agricultural yields of the last half-century have been achieved largely through the utilization of steadily increasing amounts of energy. Until the mid-1950's, total agricultural yields increased more rapidly than energy usage, but since then, the rate of increase in energy use has been faster than the increase in yields (*1*). Not only does a farm use energy directly to power machinery and in the form of fertilizers, for example, but energy has indirectly led to greater agricultural production by eliminating the necessity for woods formerly used for household fuel and for pastures required by draught animals. Transportation and the processing of foods have also reduced food imbalances over space and time, enabling the products of all agricultural land to be fully and efficiently used.

If the current concern about future scarcity of energy is justified, will there inevitably be a decline in food production? Certainly such a pessimistic hypothesis could be made on the basis of the historical record. On the other hand, an optimistic hypothesis could be based on the current profligate use of inexpensive energy and the potential for maintaining high production by increasing the efficiency of energy use. Which of these hypotheses is correct could make all the difference to the poorly fed people in the world today and to their children.

To decide between these hypotheses on other than a theoretical or conjectural basis is difficult. Of the many examples of energy-efficient forms of agriculture in less-developed countries, most have low yields (*2, 3*). The processes of population growth and economic development have been largely ones of increasing use of energy, first in terms of intensified human labor (*4*) and then in the use of fossil fuels (*5*). In the developed countries, in which scientific knowledge and technology enable the development of productive and energy-efficient agriculture, economic factors have virtually forced the extensive use of energy to increase yields and reduce manpower in order for individual farmers to survive economically. Alternative forms of agriculture are still being developed (*6*).

The Amish, however, are the exception because their religious beliefs have caused them to turn their backs on a number of energy-consuming techniques while still benefiting from modern scientific knowledge. Most Amish are not averse to having their soil and feed analyzed by specialists nor to purchasing scientifically bred stock, even though they plow with horses, ride in buggies, and live in homes without electricity. They provide an opportunity to shed some light on the question of whether high-yielding agriculture inevitably requires the heavy use of energy. This study was designed to determine (i) how much less energy the Amish use than their non-Amish neighbors and (ii) what penalty they pay in reduced yields because of their agricultural methods.

The Amish

The Amish in America and Canada now number 70,000, most of whom live in communities in Pennsylvania, Ohio, Indiana, and Illinois. They are becoming increasingly visible to the general public as a result of tourism, journalism, and television. Although the study of their agricultural methods was initiated in the early 1940's (*7*), little has been done since, even though published materials on other aspects of Amish ways have increased rapidly.

The Amish have their roots in the upheavals of the Protestant Reformation (*8*). The reaction against the authority of the Catholic church was carried over into resistance by nonconformists to the authority of the new Protestant hierarchy. The Amish were a part of this Anabaptist left wing of the Protestant Reformation, which believed in individual interpretation of the Bible and adult baptism. In the 16th and 17th centuries, they were forced from Switzerland and Germany to other countries, including Russia, where their skills as farmers were needed. But in each country their nonconformist ways led to persecutions until they reached North America in the 18th century. The Amish, who in religious and agricultural matters were progressive for centuries, are now felt to be one of the best available sources of information on the farming life of 16th-century Germany (*9*).

The religious functions of Amish agriculture are complex. Farming is not one among many neutral occupations but is strongly preferred as the optimum setting for the good life. This orientation stems most directly from their interpretation of Genesis 1:28, which directs humanity to replenish the earth and have dominance over animals and the land. They have a strong affinity for nature as God's work, as beautiful and orderly. Secondary choices are trades related to farming, such as carpentry, blacksmithing, and harness-making. Hard work is a moral value, which provides a context for the generally disciplined life. A simple technology is constantly adjusted to the right mix of sufficient labor intensity to provide jobs for the family and sufficient profitability to buy land, pay taxes, and support the shared obligations of the Amish community to cope with such problems as fire losses and medical bills. Education through the 8th grade is provided in their own schools. No government assistance is accepted, including social security or agricultural support programs, although they will consult agricultural advisers. They speak a dialect of German, and they refer to their non-Amish neighbors as "English."

The Amish belief in the literal interpretation of the Bible provides the basis for community integration. The biblical mention of horses but not of motorized

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vehicles has kept the scale of Amish communities small, the size being based on the power of the horse-drawn plow and the range of the buggy. In II Corinthians 6:14 it says, "Be ye not unequally yoked together with unbelievers," which the Amish interpret as forbidding their being tied directly to secular society by electrical lines or natural-gas pipelines. But in the modern era, many interpretations must of necessity be arbitrary when biblical wording does not apply directly to current questions. This fact, when combined with the independence of each Amish community, has led to much differentiation among them. Some Amish drive cars and are almost indistinguishable from the Mennonites, from whom the Amish split in 1697. But even among the Old Order Amish, the most numerous group, there are the very conservative who permit only stationary engines to drive belts for power (most Old Order Amish pull motorized balers behind their horses and may have a number of engines to power milking machines, refrigeration units, feed grinders, washing machines, and so forth). A market town in central Pennsylvania may have buggies of four different colors—white, yellow, grey, and black—indicating these different groups of Old Order Amish.

The market system of the larger society sets important constraints that the Amish must adjust to (*10*). The price of land, the market for agricultural commodities, interest rates, and national economic factors all influence Amish operations. Since the Amish draw an ethical line between owning a machine and hiring custom agricultural work, they are beginning to use their neighbors' machinery, especially for specialized operations such as soybean harvest and the production of silage. The constraints of an ethically determined intermediate technology produce spatial differences in Amish agriculture as well. The Amish are not likely to spread into the Great Plains because that region is not conducive to the labor-intensive, unirrigated agriculture at which the Amish are so skilled (*11*). The Amish not only must find the right area, but they must be able to purchase enough small farms to support their community and institutions without driving land prices too high. It is also desirable that a local market be available where they can sell the products of their gardens, barnyards, and farmhouses.

The Amish must adjust to the economic conditions as they find them, but in one major way they create their own economic pressures. The Amish family includes an average of seven children (*12*), and the greatest task facing an Amish farmer is to see his sons established on farms. In their attitudes toward children, the Amish are like traditional agricultural societies worldwide.

Energy Analysis

With the increased realization that energy, which is essential to modern society, may become scarce, energy analysis has increasingly become a supplement to other methods of analyzing questions concerning resources and the environment. As with economic analysis, energy analysis permits different production processes to be compared, except that the costs are in terms of the energy degraded to obtain a desired product rather than of the dollars spent. Energy analysis is especially useful when imperfect markets or hidden subsidies distort prices and make economic analysis difficult, as is often the case with energy and agriculture. Energy analysis has provided a new understanding of policy questions as diverse as packaging (*13*), housing (*14*), and transportation (*15*). One of its key advantages is that it is not culture bound, as economic analysis so often is. It has been used effectively, for instance, to show that the use of cows in India is a sensible practice in that cultural context. Cows provide milk (the major source of animal protein in the Indian diet), motive power for farm work and transport, and dung (which, in most cases, is the only fuel available). In addition, the cows are fed with materials that would otherwise be largely wasted (*16*).

However, the process of carrying out an energy analysis is rarely as straightforward or concise as the laws of thermodynamics would suggest. Many studies of the same processes have led to different findings (*17*), and international efforts have been initiated to standardize approaches and terminology (*18*). Although standardization will be a great help, it will not resolve all the difficulties because of the necessity for tailoring each analysis to the objectives of the study.

In this study, the energy uses of Amish and "English" farmers were compared by calculating their energy ratios (sometimes called caloric gain), the amount of food energy produced per unit of energy spent to produce it (*2, 19*). An energy ratio greater than 1.0 indicates that the process is a net producer of energy, and an energy ratio of less than 1.0, that it is a net consumer. The energy inputs to the agricultural process are traced back to the point at which additional energy costs make an acceptably small difference in the total energy costs. Outputs are calculated at the farm gate, on the basis that they are subsequently dependent on the allocation decisions of society rather than on the decisions of the farm operator.

In order to determine the penalty paid in lost production for energy conservation, the yields per acre (1 acre = 0.405 hectare) of each farm were determined. The total farm output, expressed in terms of 1000 kilocalories (Mcal) is divided by a corrected figure for farm acreage. The corrected acreage is obtained by adding to the total tillable land an additional acreage that would have been necessary to produce the supplemental feed that many farmers purchase. Acreages of woods and waste were not included, and rough pasture was discounted according to its equivalence to tillable land; the farmer suggested the terms of the trade, such as 3 acres of hillside pasture for 1 acre of tillable land.

The energy values of the major farm products are given in Table 1. For some, such as milk, eggs, and grains, the energy values are obvious. These are homogeneous commodities of relatively little variation in quality or nutritive value. With animals, however, there are large variations based on size, age, and quality of the animal. The product itself is complex: how should the analysis distinguish between prime meat cuts of low caloric value with high caloric fat and animal byproducts? The approach used here is that of Cook (*20*), which assumes a standard percentage of the carcass to be separable lean meat, with bone and excess fat removed. The energy output per animal is, of course, more a function of these assumptions than a straightforward energy accounting, and as a result, the matter of whether a process is a net energy producer or consumer becomes less meaningful. However, these necessary assumptions do not impair the *comparisons* of energy ratios and yields between Amish and English farmers; indeed, any assumption of caloric values that is based on the weight of a fairly standard animal product would lead to the same relative responses to the questions posed by this study.

Table 2 gives the energy values used to convert major inputs into caloric values. For the most part, they are averages of selected data available in the literature, weighted to account for completeness of analysis and appropriateness for this study. Most energy figures that are available for agricultural inputs vary considerably. Not only do major differences stem from the completeness of the analysis, but also, fertilizers are produced by different processes, feeds come from different regions (some with irrigation and others without), and the use of different forms of energy and transportation all contribute to the differences in conversion figures. Agricultural equipment is particularly difficult to handle since there are normally many pieces on a farm, each of which has different rates of use, which makes the calculation of energy depreciation rates awkward.

Solar and human energy are not included in the analysis. Solar energy is considered a free good; if it were not used by agriculture it would go essentially unused. Human energy, even on the Amish farms, is still a tiny fraction of the total energy used, even though the work begins early, often 5 a.m., and ends with the after-dinner chores. There is also the question of whether labor would be more correctly viewed from the Amish perspective, as a benefit rather than as a cost.

Table 1. Energy values of major food products (*25*).

Item	Energy value (kcal)
Milk	650*
Eggs	972†
Hogs	3,040‡
Cows	2,440‡
Chickens	1,035‡
Corn	3,480§
Wheat	3,300§
Soybeans	1,340§

*Per kilogram, with 3.5 percent butter fat. †Per dozen, large. ‡Per kilogram of live weight. §Per kilogram.

Research Procedure

Three groups of Amish were studied—in central Pennsylvania, eastern Illinois, and southwestern Wisconsin—in order to obtain results from different environments. A smaller number of English farmers in the same areas were also interviewed. In Wisconsin, several recently completed studies (*21, 22*) provided comparative data, which necessitated a somewhat modified analysis and different conversion figures. Each farmer interviewed was asked a series of questions about the quantities of materials brought onto the farm and of the products sent out. Data were confirmed where possible by checking with distributors of fuel, feed, and fertilizer.

The number of horses used on each Amish farm was quite consistent. There were usually eight work horses or mules, even though farm size varied considerably. The number of "driving" horses varied more, between one and two in Pennsylvania to between two and four in Illinois. The Amish contend that a work horse will eat as much as a cow, which is an indication of one energy cost the Amish must overcome if their yields are to equal those of the English.

An input-output analysis such as this has the advantage of simplicity, since it is essentially concerned with what comes onto each farm and what leaves it; however, it sheds little light on the internal operations of each farm. The farmer is assumed to be using his land reasonably, given the constraints he operates under. The analysis assumes that the results will reflect the different constraints of labor and energy operated under by both the Amish and the English. However, there are variations among the farms. The Amish produce much of their own food and sell surplus vegetables, fruits, eggs, and baked goods at local markets. Theoretically, the food purchased and sold by each farm family should be included in the energy analysis, but such data are hard to obtain and were not a part of this study. Also, different farmers produce different crops and use different forms of crop rotation; the effects of these variables are unknown. It is not the highly controlled experiment that may be desired, but the results do reflect a substantial difference between Amish and English use of energy.

Results

Central Pennsylvania. The study area is one of ridges and valleys just east of the Allegheny Front. The Amish have moved here only within the last 10 to 15 years, as land prices, tourism, and industry in Lancaster County have made it difficult for them to find farms for their growing numbers in that traditional center of Amish life. The Amish are now found in 40 of Pennsylvania's 67 counties. The valleys of central Pennsylvania provide good limestone soils, a degree of isolation, wooded hills, and good supplies of water. The sample consisted of 12 farms belonging to the Old Order Amish, five to the most conservative group of Amish (locally known as Nebraska Amish), and six English farms. All are primarily milk producers.

The overall energy ratio of the Old Order Amish indicates that there is virtually no net gain in energy in their dairy operations (Table 3), but in its final form of milk, the energy is directly useful to man. The English farmers' energy ratio of 0.553 means that they use 83 percent more energy to produce a unit of milk than the Amish. The yields per hectare for the two forms of agriculture are much the same, with the Amish yields 4 percent higher. In this case, there is no penalty in reduced production stemming from the reduced energy use of the Amish, which supports the optimistic hypothesis that high production can be maintained with reduced use of energy.

For the Nebraska Amish, however, the historical relationship between ener-

Table 2. Energy costs of major inputs.

Item	Energy cost (Mcal)	Efficiency of production (%)	References
Fuels			
Gasoline	9.30*	89.6	*2, 26*
Diesel	10.40*	89.6	
Liquefied petroleum gas	6.45*	95.0	
Kerosene	10.30*	84.6	
Naptha	7.70*	89.6	
Electricity	2.54†	34.0	
Fertilizer			
Nitrogen	15.9‡		*2, 3, 27, 28*
Phosphorus	3.5‡		
Potassium	1.4‡		
Pesticides			
Atrazine	45.2‡		*2, 28–30*
All others	33.0‡		
Feed			
Corn	1,300§		*28*
Soybean meal‖	1,100§		*2, 3, 30*
Hay	400§		*3, 20, 28, 30*
Transport	0.345¶		*2, 3, 20*
Farm equipment	160#		*1–3*

*Per liter. †Per kilowatt hour. ‡Per kilogram. §Per ton. ‖The total energy cost to produce a ton of soybeans, estimated to be 2200 Mcal, is divided equally between the soybean oil and meal. ¶Per ton per kilometer. #Per horsepower per year. For Amish farms, the number of motors and their horsepower were recorded. For non-Amish, who power most of their farm implements from tractors, the horsepower of the tractors was doubled to account for their other equipment.

gy use and yields appears. Their energy ratio is 49 percent higher than that of the Old Order Amish, but their yields are 47 percent lower. Since they use only one stationary engine, the Nebraska Amish must sell their milk as grade B milk, cooled only by spring water. In addition, they are less likely to take advantage of the services offered by agricultural extension agents and farm suppliers. Their farms are 27 percent smaller than those of the Old Order Amish, but they have many fewer cows, in part because they do not use milking machines. The Nebraska Amish generally reflect greater self-sufficiency. The farms appear noticeably poorer, and the farmers are more reluctant to be interviewed. The Nebraska Amish can perhaps best be thought of as failing to utilize the scientific developments as extensively as other Amish and are therefore similar to farms in less-developed countries.

Figure 1A provides a comparison of the major energy inputs per hectare for the three groups. The main energy savings of the Amish come in their use of fuel and equipment, as would be expected. The Old Order Amish use more purchased feed than the English; 100 acres (40.5 hectares) is about the limit of horse farming, and many farms have fewer tillable acres than that; if the Amish wish to have additional cows they must purchase additional feed.

An additional contrast between the Amish and the English is their household use of energy. The Amish use liquefied petroleum gas for cooking, refrigeration, and hot water; naptha for lighting (in Coleman lanterns); and wood for space heating. The English use energy in much the same way as most American families do. In our sample, the average Amish family used 15,330 Mcal per year, and the English families used 160,280 Mcal. The English, in fact, used 20 percent more energy in their homes than the Amish to produce 173,650 kilograms of milk, the average farm output. The conservation achievements of the Amish here are greater in their homes than in their farming.

Eastern Illinois. The Amish community in Douglas County, Illinois, was established in 1864 with the purchase of railroad land for $8.10 per acre. The land is excellent, with deep fertile soil, although its flatness creates some drainage difficulties. The uniformly good soil presents a problem to the Amish since it does not permit them to allocate any of it to woods and the 5 to 15 acres used as pasture on each farm are inefficiently used in comparison with the English farms. In the absence of woods, household heating is by fossil fuels, and in the absence of gravity-fed water systems, windmills are used to lift water to insulated water tanks.

As Amish farms dominate this part of Douglas County, it was not possible to pair Amish farms with adjacent English farms. The nearest English farms were substantially larger than the Amish farms; the five English farms surveyed averaged 495 acres (200 ha) compared with 96 acres (39 ha) for 11 Amish farms. The Amish use very little chemical pesticides and, because of the good soil in the area, they have traditionally not used chemical fertilizer, although some farmers are beginning to apply small amounts (some organic fertilizers are used). However, unlike another recent study of organic farming (*23*), we found that the Amish yields of corn, 115 bushels per acre (7200 kg/ha), are less than the English figures of 165 bushels per acre (10,400 kg/ha). The largest single energy input to an Amish farm is for supplementary feed (especially soybeans) which is grown in only limited quantities (Fig. 1B). Hogs are the major product in the area, although the English farmers export substantial amounts of grain as well.

The initial calculation of the energy ratios (Table 4) reflects the grains exported by English farmers, which pushes their energy ratios above 2.0. Since it would not be correct to compare outputs of animal products to grain, a calculation was made of the hogs that could be produced if the exported grain had been fed to hogs, using local feeding efficiencies of 4.25 kg of grain per kilogram of animal weight gain. A 15 percent energy surcharge was added for the estimated energy cost of this hypothetical feeding operation. On this basis, the energy ratio of the Amish was 25.3 percent higher than that of the English, but their yields were 38.1 percent lower. These results support the pessimistic hypothesis, that a decline in energy available to agriculture would cause a decline in food production.

There are several possible explanations for the differences in the results from Illinois and Pennsylvania. The use of chemical fertilizers would increase Amish yields significantly, but it would also lower their energy ratios toward the English figures, thus generally reducing the differences between the two farming operations. It is also possible that hog farming, being less labor-intensive than dairy farming, is less amenable to energy conservation through Amish methods. However, since crop production is

Table 3. Energy ratios and yields per farm (central Pennsylvania). Summary data are shown in boldface type to facilitate comparison with data in Tables 4 and 5.

Group	Energy ratio	Yield (Mcal/ha)	Output (Mcal)	Input (Mcal)	Size (ha)	Corrected size (ha)	Cows (N)
Old Order Amish	**1.009**	**3,151**	134,527	113,367	32.6	42.7	31.0
English	**0.553**	**3,071**	245,715	444,453	73.4	80.0	47.3
Nebraska Amish	**1.508**	**1,710**	53,014	35,151	30.0	31.0	12.8

Table 4. Energy ratios and yields per farm (eastern Illinois). Summary data are shown in boldface type.

Group	Energy ratio	Yield (Mcal/ha)	Output (Mcal)	Input (Mcal)	Size (ha)	Corrected size (ha)
			Data as collected			
Amish	**0.974**	**3,165**	173,134	177,821	38.9	54.7
English	**2.003**	**11,444**	2,466,156	1,230,769	200.6	215.5
			Assuming all grains fed to hogs			
Amish	**0.886**	**2,879**	157,494	177,821		
English	**0.707**	**4,644**	1,000,820	1,415,384		

Table 5. Energy ratios and yields per farm (southwestern Wisconsin). Summary data are shown in boldface type.

Group	Energy ratio	Yield (Mcal/ha)	Output (Mcal)	Input (Mcal)	Size (ha)	Corrected size (ha)	Cows (N)
Amish	**1.614**	**1,305**	50,631	31,379	60.8	38.8	14.5
English							
Small farms*	**0.274**	**1,668**	99,399	362,990	71.6	59.6	24.5
Large farms†	**0.395**	**2,079**	204,800	518,890	107.6	98.5	40.9

*Number of cows, < 30. †Number of cows, 30 to 49.

the major energy consumer, it seems unlikely that this factor would be important.

The differences between the two sets of results probably stem from the differences between the two environments. The diversity of central Pennsylvania, with its long narrow valleys, steep wooded hills, and marginal pasture, can be used efficiently by the Amish, while the uniformly good soil of Illinois is ideal for modern agricultural technology. Each environment presents certain obstacles and opportunities, and although it is easy to visualize the obstacles to using large machines on the irregular topography of Pennsylvania, it is not so easy to identify the obstacles to the Amish in Illinois. Household uses of energy are not included in these figures. In fact, since the energy ratios and yields of the Amish are similar in Illinois and Pennsylvania, it is probably more correct to say only that the Amish cannot utilize the Illinois site as effectively as the English.

The differences between the results for Illinois and Pennsylvania suggest that if energy were to become scarce in the future, the changes in agriculture would vary depending on the site. In diverse environments, agricultural practices may move away from energy-intensive methods more rapidly than in areas that are now treated most intensively by modern methods. If labor is substituted for increasingly expensive energy, idle small farms may be returned to production to the extent that they permit the utilization of local energy sources such as woods and pastures. Sites that enable farmers to avoid the high cost of equipment and fuel will increasingly be advantageous.

Southwestern Wisconsin. Vernon County and the adjacent part of Monroe County is the site of the Cashton-Westby Amish

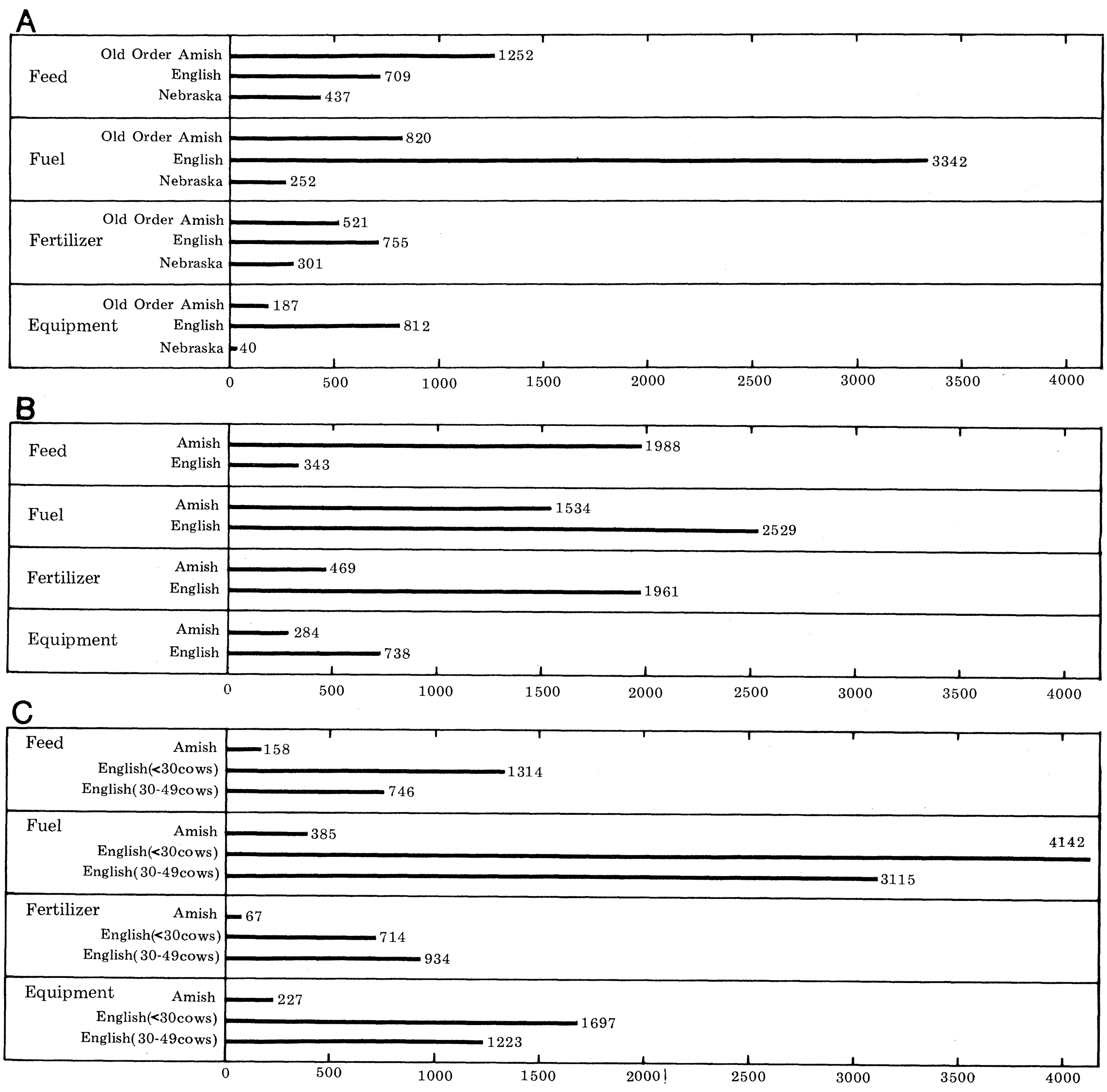

Fig. 1. Major energy inputs per hectare for Amish and English farms in (A) central Pennsylvania, (B) eastern Illinois, and (C) southwestern Wisconsin.

settlement. Consisting of approximately 55 farms, the community has been expanding as Amish have moved in from other areas where land pressure and prices are higher. The Amish here are conservative, in many ways similar to the Nebraska Amish in their use of stationary engines and belt power and the limited use they make of available scientific assistance. The region is characterized by a rolling upland topography cut by flat-bottomed valleys, with rocky, wooded slopes making up much of the landscape between. The soils are deep forest soils overlying dolomite and sandstone, but the farms are large because of the amount of unproductive land on the hillsides. Dairy farming predominates, and nearly all cropland is planted with corn, hay, and oats.

Data were collected from ten farms in this settlement and were compared with a statistical sample of 14 farms obtained from the 1975 Wisconsin Farm Business Summary (*21*) and with supplementary data from other sources (*22*). While not providing a sample of farms in the same area, this sampling method did offer the opportunity to select English farms of the same approximate size and with the same number of cows; thus, differences in these variables should not affect the outcome. However, compared with English dairy farms in Pennsylvania, the small English farms (with an average of 24.5 cows) were relatively inefficient in their use of energy, and yields were less. Therefore, a sample of larger Wisconsin farms (30 to 49 cows) were also evaluated to see if the scale of operation affected the results.

The energy conservation of the Amish is striking (Table 5). The Amish yields are 22 percent less than those of the smaller English farms and 37 percent less than those of the larger ones, and yields on all types of farms are well below those in Pennsylvania. The Amish inputs for all major items—feed, fertilizer, fuel, and equipment—are low, whereas for the English farms they are high, especially for fuel (Fig. 1C). The data for English farms in all three study areas suggest that larger farms are more energy-efficient than the smaller ones.

Conclusions

The data do not clearly support either the optimistic or the pessimistic hypothesis. The results from the more progressive Old Order Amish in Pennsylvania, who perhaps best approximate a traditional culture taking advantage of modern science and technology, do support the optimistic hypothesis, but the Amish in Illinois, who are progressive in most matters, do not. A number of other factors, such as the effects of different environments and the differences in farm size and operation, are also important. An input-output analysis such as this does not permit a detailed understanding of the specific reasons for the variations. To obtain the data necessary for such an analysis would require the collection of a vast amount of information from each farmer throughout the year and necessitate a degree of involvement in the farm operation that Amish farmers may not be willing to grant. Even with such data, the interrelationships might not become clear.

In one respect, however, the results are clear and do support the optimistic hypothesis, if slightly modified to pertain to energy conservation on farms in general rather than just in agricultural production. An Amish farmer told us that to buy a car he would have to milk five more cows. One may ask how many cows it would take to purchase a recreation vehicle or a color television or to pay an electric bill. If the Amish are conservationists, it is primarily in their consumption pattern. Their major contribution to energy conservation is in the limited demands they make on available resources to support their way of life. Their major purchases are limited to clothing, bread flour, sugar and a few other food items, and household equipment and furnishings. The Amish buggies and harnesses, which are made by Amish craftsmen, will last 20 to 30 years; a horse may live that long as well, although the average life span is approximately 20 years. Probably more than any other group in this country, the Amish could survive without the support of industrial society.

Amish conservation and its economic consequences also account for the prosperity and expansion of Amish agriculture, a striking factor in itself in this era of poverty-stricken small farms and large commercial agriculture. The frugality of their consumption patterns and their willingness to use a labor-intensive intermediate technology has meant that the Amish could bank most of the proceeds of their farming operations and accumulate the funds to obtain land for their sons as the need arises. Their simple technology has enabled the Amish to avoid the major causes of small farm poverty and bankruptcy, the difficulty of obtaining the capital to purchase modern agricultural machinery or the heavy debt payments required if it is obtained (*24*).

If energy becomes scarce in the future, the effects will not be felt uniformly. Agriculture would almost certainly be able to procure supplies needed for energy-efficient purposes such as fertilizing crops and preserving food. Even though the results we have described are mixed, they do suggest the potential for reintroducing human labor without major losses in production as long as key supplies such as fertilizers are available. The requirements of human labor could even be a benefit if energy shortages reduced the jobs available in other sectors of the economy.

The Amish experience should make us more confident about the future if energy should become progressively scarcer. It is often said that the Amish provide a vignette of early America; is it also possible that they may provide an image of the future?

References and Notes

J. S. Steinhart, and C. E. Steinhart, *Science* **184**, 307 (1974).
2. G. Leach, *Energy and Food Production* (International Institute for Environment and Development, Washington, D.C., 1975).
3. M. Slesser, *J. Sci. Food Agric.* **24**, 1193 (1973).
4. E. Boserup, *The Conditions of Agricultural Growth* (Aldine, Chicago, 1965).
5. R. G. Wilkinson, *Poverty and Progress: An Ecological Perspective on Economic Development* (Praeger, New York, 1973).
6. R. Merrill, Ed., *Radical Agriculture* (Harper & Row, New York, 1976).
7. W. M. Kollmorgen, *Rural Life Stud. No. 4* (U.S. Department of Agriculture, Washington, D.C., 19 *Am. J. Sociol.* **49**, 233 (1943).
8. J. A. Hostetler, *Amish Society* (Johns Hopkins Press, Baltimore, 1963).
9. W. I. Schreiber, *Our Amish Neighbors* (Univ. of Chicago Press, Chicago, 1962), pp. 88–98.
10. V. Stoltzfus, *Rural Sociol.* **38**, (1973).
11. E. W. Schwieder and D. A. Schwieder. *A Peculiar People: Iowa's Old Order Amish* (Iowa State Univ. Press, Ames, 1975).
12. H. E. Cross, *Nature (London)* **262**, 19 (1976).
13. B. M. Hannon, *Environment* **14**, 11 (1972).
14. A. Mackillop, *Ecologist* **2** (No. 12), 4 (1972).
15. E. Hirst and J. C. Moyers, *Science* **179**, 1299 (1973).
16. S. Odend'hal, *Hum. Ecol.* **1**, 3 (1972).
17. B. F. Chapman, *Energy Policy* **2**, 91 (1974).
18. International Federation of Institutes for Advanced Study, *Energy Analysis Methodology, Workshop Rep. No. 6* (Nobel House, Stockholm).
19. G. H. Heichel, *Am. Sci.* **64**, 64 (1976).
C. W. Cook, *J. Range Manage.* **29**, 268 (1976); _____, A. H. Denham, E. T. Bartlett, R. D. Child, *ibid.*, p. 186.
21. *Wisconsin Farm Business Summary, 1975* (Univ. of Wisconsin Extension, Madison, 1976).
22. U.S. Department of Agriculture, *Agric. Inf. Bull. No. 230* (1968); _____, *Selected U.S. Crop Budgets: Yields, Inputs and Variable Costs* (1971), vol. 2.
23. W. Lockeretz, R. Klepper, B. Commoner, M. Gertler, S. Fast, D. O'Leary, R. Blobaum, *Center for the Biology of Natural Systems Rep. No. CBNS-AE-4* (1975).
24. E. Higbee, *Farms and Farmers in an Urban Age* (Twentieth Century Fund, New York, 1963), p. 47.
25. A. L. Merrill and B. K. Watt, *Energy Value of Food, U.S. Department of Agriculture Handbook No. 74* (1963).
26. *Handbook of Tables for Applied Engineering Sciences* (Chemical Rubber Co., Cleveland, 1970), p. 304; V. Cervinka, W. J. Chancell, R. J. Coffelt, R. G. Curley, J. B. Dobie, B. D. Harrison, *Trans. Am. Soc. Agric. Eng.* **18**, 246 (1975).
27. W. Lockeretz, R. Klepper, M. Gertler, S. Fast, D. O'Leary, *Center for the Biology of Natural Systems Rep. No. CBNS-AE-6* (1975).
D. Pimentel, L. E. Hurd, A. C. Bellotti, M. J. Forster, I. N. Oka, O. D. Sholes, R. J. Whitman, *Science* **182**, 443 (1973).
29. M. B. Green and A. McCulloch, *J. Sci. Food Agric.* **27**, (1976).
30. B. Commoner, *Center for the Biology of Natural Systems Rep. No. CNBS-AE-1* (1974).