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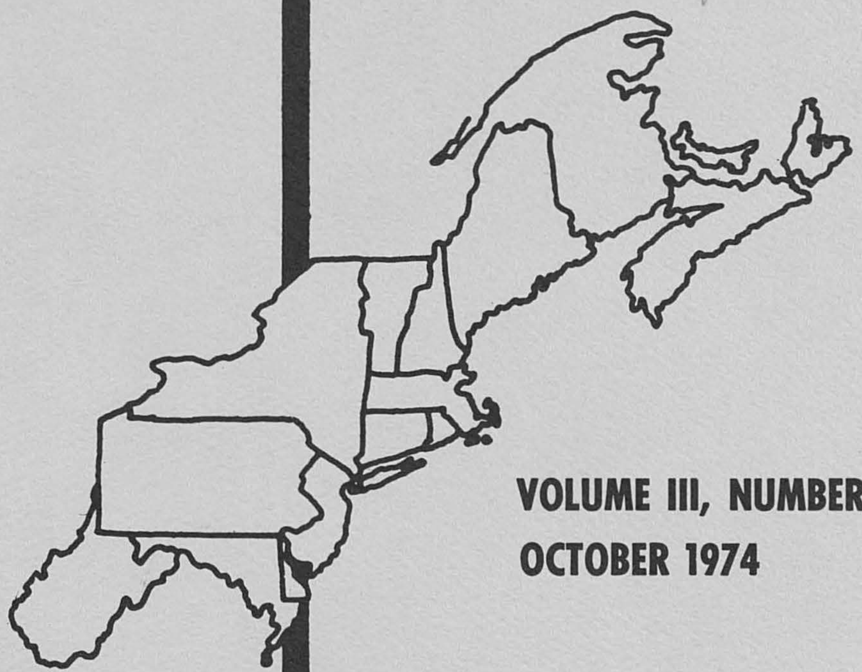

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THE TWO-WAY STRETCHES IN CONTEMPORARY AGRICULTURE

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Introduction

When my father was growing up on a farm in Appanoose County, Iowa, his environment, except for a clock made in Connecticut, was largely homegrown. The homegrown even included the hay-burners that pulled the plow and the timothy that they burned. I have brought home to Connecticut the clock that my grandfather bought from a peddlar, but time has changed almost everything else. The Lockwood Farm of the Connecticut Station is the source of some of the changes, and it shows all of them clearly. There is, of course, the hybrid corn that was invented on the Farm, but there is also a tractor made in the Middle West burning oil pumped from the Middle East and pulling a Dutch sprayer full of fungicide from Pennsylvania. The workers were born in other states as I was, and they spread fertilizer from Tennessee and plant seeds from Idaho. To conclude the contrasts between eras, I can say that my father may have gone to the annual fair in a nearby Missouri county, but he had to enlist in the AEF to see Europe, which is a tour my son can now take for a couple of weeks wages.

The swift changes reflected in my family story are the forces that have created contemporary agriculture, shaken Americans to the soles of their shoes, and altered the global environment. My role here is to tabulate some features of modern agriculture, to examine how it has been shaped by our choices amongst competing goals, to remark upon shadows cast by the future, and to conclude optimistically.

Characteristics of Contemporary Agriculture

The features of contemporary agriculture are illuminated by contrasting it with the farming in the late 19th Century, which is as yesterday in the long history of man growing crops. The contrasts will be seen in simple tables largely drawn from the Agricultural Statistics of the U. S. Department of Agriculture. The history extends from 1870 to 1970 with some shortenings where the statistics were not at hand.

The fundamental factor of people to be fed, farms to grow the food, and the acreage used by the farmers are tabulated in Table 1. One sees the continuous, exponential rise of population. The number of farms rose to a maximum of nearly 7 million during the school of hard knocks run by America in the mid-30's and subsequently halved. Cropland rose to twin maxima -- one in 1930 and another when America fed the victims of WW II. Thus contemporary agriculture is roughly 2½ million farms where there were 7 million when I was a boy, and they feed a population equal to the Americans of 1930 plus the population of 1900, all from a fifth fewer acres.

Table 1
Changes in Population, Farms and Crop Acreage,
U. S., Selected Years

Year	People	Farms	Crop Acres
	----------------------	millions	--------------------
1880	50	4	166
1900	76	6	283
1930	123	6	359
1964	192	3	286

Feeding people abroad must be in any appraisal of contemporary agriculture. The rise of the export of corn for animals and wheat for people is clear in Table 2. The drama of 1972 tops all: exporting the produce equivalent to 30 percent of harvested cropland in America.

Table 2
U. S. Exports of Corn and Wheat

Year	Corn	Wheat
	--------millions of bushels-----------	
1870	18	52
1900	153	220
1930	3	131
1970	506	715

The trick to feeding more people on fewer acres lies, of course, in raising crop yields, preventing pests from diverting the crop to their use, and feeding the crop directly to people as bread and beans rather than via an intermediary, a cow, pig or chicken. Contemporary agriculture is doing some of these things. The acreage tilled for corn is only half more today than it was a century ago, while the grain has increased 3½-fold (Table 3). The story of increased yields per acre is much the same for wheat. It is reasonable to assume part of this increase comes from pest control.

Table 3
Millions of Acres and Billions of Bushels

Year	Corn		Wheat		Soybeans	
	A	Bu.	A	Bu.	A	Bu.
1870	38	1	21	.3	--	--
1900	95	3	49	.6	--	--
1930	85	2	63	.9	1	.01
1970	57	4	44	1.4	42	1.12

If the farmers were feeding more people per acre by feeding plants to people instead of cows, Table 3 would show a greater rise in the food grain, wheat, than in the feed grain, corn, and it does not. Nevertheless, there is an inkling of more direct consumption of crops by people: vegetable protein that can extend or be engineered into a replacement for meat is made from soybeans, and soybean production increased 80-fold between 1930 and 1970.

For the time being, however, contemporary agriculture is raising lots of meat. Although dairy cows increased to a maximum near the end of WW II and have decreased precipitously since, the number of other cattle has risen seven-fold in the century (Table 4). Chickens have increased even more sharply. Thus more people are fed per acre despite an increase in the queue of meat animals and birds feeding between man and plant. The increasing consumption of plants by man that is suggested by the rise in soybean production is reflected in fats, not meat: although the average American ate a fifth more red meat and

Table 4
Changes in Cattle Numbers, U. S., Selected Years

Year	Dairy	Other
	---------------millions---------------	
1870	10	14
1900	17	51
1930	23	41
1970	14	98

three times as much poultry in 1970 as in 1910, his consumption of animal fat declined to less than half while vegetable fat increased four-fold.

Although the cows and chickens at the feed trough have increased, another animal, the horse, has stepped back. Tractors and trucks on farms increased 6 million between 1930 and 1970 (Table 5), and at the same time the acreage for horse and mule feed decreased 60 million, a saving nearly equal to the one-fifth decrease in cropland between 1930 and 1970.

Table 5
Tractors and Trucks on U. S. Farms

Year	Tractors	Trucks
1930	0.9	0.9
1970	4.6	3.0

Fertilizer is another feature of contemporary agriculture. The first American experiment station was established in 1875 to transplant Liebig's agricultural chemistry from Germany to Connecticut to prevent cheating on fertilizer. Only in our generation, however, has its use burgeoned, Table 6. Pesticides are another hallmark of contemporary agriculture, and they increase the number of people that can be fed from an acre. A fair audit of modern efficiency must show the debit of fertilizer and pesticide brought onto cropland from outside the farm.

Table 6
Changes in U. S. Fertilizer Use

Period	N, P_2O_5 and K_2O
	(million tons)
1940-44	2
1950-54	6
1960-64	9
1970	17

Hybrid plants typify modern agriculture. The economics of the introduction of hybrid corn has been thoroughly studied *[6]* and its advent is summarized in Table 7 *[8]*. More than a decade passed between

D. F. Jones' invention of double-cross hybrids on the farm of The Connecticut Station and the first entry in the Table, but within another decade half the corn was hybrid and after another 20 years there was scarcely anything else. The advent of hybrids was accompanied by increased fertilization, and hybrids and fertilizer were primary factors in more than doubling the corn yields that had only oscillated between 18 and 30 bushels per acre for 60 years.

Table 7
Corn and Hybrids in U. S. and
Plant Food in Illinois

Year	% Hybrid	Plant Food (1,000 tons)	Bu./A
1933	0.0	--	23
1938	15	--	28
1943	52	28	32
1953	86	294	40
1963	95+	821	68

Source: *[8]*

The final feature of contemporary agriculture that I will illustrate is irrigation, which more than doubled between 1939 and 1969, Table 8. Since a quarter of the irrigated land is in the single state of California, one can get a glimmer of the impact of this water upon contemporary agriculture by noting the simultaneous decrease in acreage of vegetables in the Eastern States, and its increase in California.

Table 8
Changes in Irrigated Acres and Acreage
in Vegetables Between 1939 and 1969

		Vegetables		
Year	Irrigated	North Atlantic	South Atlantic	California
	millions of acres			
1939	18	404	671	490
1969	39	338	609	688

These few tables exemplify present agriculture in America, which feeds many people well from a declining acreage. This has been accomplished by growing two ears where one grew before and saving those ears from the competitors we call pests, not by causing people to eat more plants directly rather than cycling the plants through animals. It has been accomplished by putting botany to work in making better crops, by raising poultry more efficiently, and by importing petroleum, fertilizer and pesticides onto the farms that were once nearly self-sufficient.

Competing Goals

If the course of a nation is examined, one can surmise that certain paths were taken to reach one among competing goals. We may then perceive how we reached our present agriculture and even understand the goals that must be relinquished and the alternatives that must be chosen if we would take a new path to a different agriculture. These generalities will, I hope, come clear as I get down to particulars.

Since examples are more enlightening if timely, I'll begin with a couple related to energy, something that seems in short supply today. As high prices and empty tanks push us toward the goal of saving fuel, what goals must we relinquish? A purely agricultural example can be found in a speech by the Secretary of Agriculture *[2]*, which began "America is fuel hungry." A sacrificed goal is suggested by his saying "Work the field the long way", a practice that will surely save fuel but may not conserve soil through contour plowing. Another goal marked for sacrifice is brought to mind by a hope of Assistant Secretary R. W. Long *[14]*: "The flying freight cars of tomorrow will bring a great variety of tropical fruits and vegetables..." Because a Boeing 747 gets only 11 cargo ton miles/gallon instead of the 100 to 200 of a train or barge *[13]*, the goal of fresh produce borne by air from the tropics will probably be relinquished. These two leaders of agriculture, trying to plow the best furrow among the stumps and rocks, epitomize the choices among competing goals that a nation must make, and they help move my story from generalities to particulars.

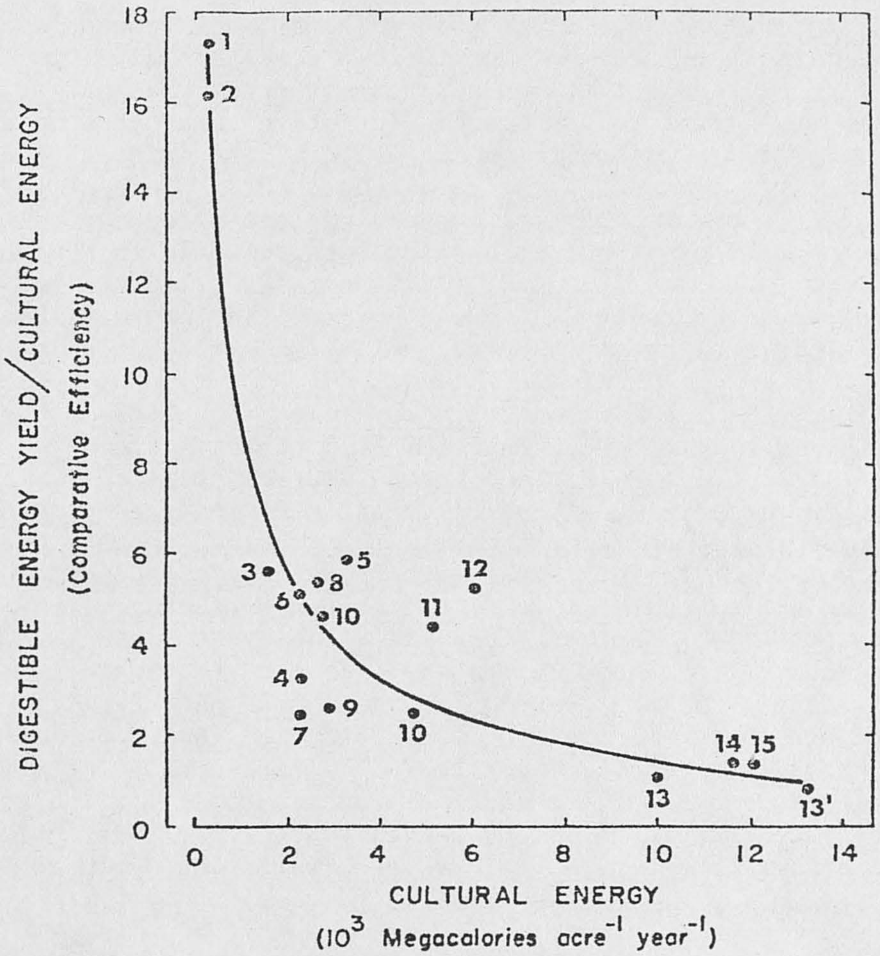
The goal of efficiency would seem the landmark without peer or competitor that has guided us to contemporary agriculture, but the seeming lack of competition is an illusion concealed in the word efficiency. My dictionary defines efficiency as effectiveness compared with costs in energy, time, money, etc. Thus saying the goal is efficiency says nothing until one has chosen the divisor among the competitors: energy, time, money, etc. If the divisor of money is examined closely it, too, turns out an index of the competition among goals as human interest varies among stocks and bonds, land and buildings, greenbacks and gold, petroleum and sweat. Despite all this uncertainty, however, efficiency has often taken on a clear meaning in terms of human labor. Contemporary agriculture has plowed toward the goal of less human sweat: in 60 years the labor to produce corn and cotton has decreased to less than 10%, of potatoes and milk to about 20%, and of cattle to 39%. Poultry, of course, excels with a labor requirement decreased to 5% in only a third of a century.

An alternative to labor efficiency is energy efficiency. Heichel *[7]* has calculated how many calories were expended by man, beast and machine in producing digestible food or feed by 15 different agricultural systems (Fig. 1). The farmer invests calories of energy in tillage, harvesting, processing, chemicals and irrigation to assist photosynthesis in converting calories of sunlight into calories that man or beast can digest. If one's goal is conserving energy, the most efficient system is the one with the highest ratio of digestible calories yielded to labor, fuel and other calories invested. Surprisingly a New Guinea vegetable gardener or Philippine rice farmer captures 16 digestible calories for every calorie invested, while an American farmer growing rice, peanuts or unprocessed sugar beets captures only 1 digestible calorie for each calorie he invests. Turning to an historical comparison, Heichel calculated that in 1915 a Corn Belt farmer captured 5 calories in corn grain for each calorie invested, and in 1970 he captured about the same.

Contemporary American agriculture saves labor, not energy. All these systems from 1915 to the present are, of course, viable by the appropriate reckoning because a calorie of peanut sells for more than one of corn, and wages are different in Iowa and New Guinea. Nevertheless, these ratios show that contemporary agriculture has chosen the goal of labor rather than energy conservation, and they suggest that if we move toward energy conservation we may move away from labor conservation.

Another goal that conflicts with labor saving is job saving. We remember this conflict in the song of John Henry, the Steel-Driving Man, and it has been heard recently in the cry of "Hard Tomatoes, Hard Times" *[9]*. When a man is hoeing weeds in tattered overalls under a brassy sun, he may dream of labor saving machines; but when he is on welfare in a ratty slum, he may curse the machine that replaced him.

A kindred conflict with the goal of jobs in the countryside is foretold in an assessment of the impact of environmental controls *[3]*. A microeconomic study of fruit and vegetable canning and freezing concluded that the expense of installing and operating water pollution abatement would scarcely affect American prices or balance of payments. But the study went on to the impact on the processing plants and concluded that the cost of pollution control equipment would increase the advantage of large plants over small ones, causing small ones to close. "Many of these would be in small towns and rural areas where reemployment would not be readily available." Again, a conflicting goal -- an environmental one -- forms the horn of another dilemma with rural employment.



The caloric gain, or ratio of the yield of digestible energy to the investment of cultural energy, of 15 agricultural systems. This ratio is used as a measure of the efficiency of energy use. See Fig. 3 for explanation of number code.

The following code applies to the 15 agricultural systems in Figures 3, 4, and 5: 1. Paddy rice, Philippines, 1970; 2. Vegetable garden, New Guinea, 1962; 3. Corn for grain, Iowa, circa 1915; 4. Corn for grain, Pennsylvania, circa 1915; 5. Corn silage, Iowa, circa 1915; 6. Alfalfa-brome hay, Missouri, 1970; 7. Oats, Minnesota, 1970; 8. Sorghum for grain, Kansas, 1970; 9. Soybeans, Missouri, 1970; 10. Sugarcane, Hawaii, 1970, cultural energy excludes processing; 10'. Sugarcane, Hawaii, 1970, cultural energy includes processing; 11. Corn for grain, Illinois, 1970; 12. Corn silage, Iowa, 1970; 13. Sugarbeets, California, 1970, cultural energy excludes processing; 13'. Sugarbeets, California, 1970, cultural energy includes processing; 14. Peanuts, North Carolina, 1970; 15. Irrigated rice, Louisiana, 1970.

Figure 1. From Heichel (1973).

Land conservation is another goal we have moved towards as contemporary agriculture feeds more people per acre than did 19th Century agriculture. The land not tilled has become forests and parks, parking and highways and ordinary open space. The drive to produce more per acre is not surprising since the value of farm real estate per crop acre has more than tripled in the past score years. Some of the increase in yield has come from the burgeoning fertilizer and pesticide use; this change, too, is not surprising because while the value of cropland tripled between 1950 and 1970, the price of fertilizer and pesticides actually decreased. Through prices, society made contemporary agriculture stingy with acres and lavish with chemicals.

Unfortunately, the environment always exacts a price, and environmentalists worry about the leaking of these chemicals from field to water. In a study of many streams across America sponsored by the Council on Environmental Quality, "The most striking trend...was the dramatic worsening of nutrient trends within the nation as a whole and within every type of basin examined... These results suggest that phosphorus pollution has less to do with detergents than with agricultural runoff" *[5]*. Another study, this one by NAS, concluded, "nitrate concentrations have increased in some surface waters and decreased in others" *[16]*. Perhaps we shall back away from the goal of conserving land through increasing yield and head toward one of less use and perhaps less runoff of chemicals. Unfortunately the environment will likely exact a price for that change, too. Tilling more acres to replace the yield lost by decreasing chemical use could well cause more erosion and more silt in rivers. With apologies to Swift, I write

"A flea
Hath smaller fleas that on him prey;
And these have smaller still to bite 'em;
And so proceed ad infinitum.
Thus every environmental issue in its kind,
Is bit by the one that comes behind."

Another means of increasing yields in contemporary agriculture is irrigation. For generations Westerners have worked at a mission: "the moving waters at their priestlike task." Now the once blameless goal of reclamation is conflicting with the use of water by people who will pay more to use it otherwise and conflicting with taxpayers who will not supply irrigation water below cost. Once a cause for conservationists alone, the criticism of irrigation schemes has now been joined by the National Water Commission, and its executive director says, "Water is so important that the country can't afford in the future to give it away or make it available at less than cost" *[11]*. The goal of irrigation has, therefore, found its competitor, and the migration of crops suggested by Table 8 may slow as some crops cease their westward course or even return to land watered by rain.

One last pair of conflicting goals that I would mention is maximum present return vs. long-term security. It is akin to the conflict between investing in a gold mine prospect and buying government bonds. The examination of the genetic vulnerability to disease of our major crops, which was provided by the Southern corn leaf blight epidemic of 1970, revealed that the goal has been maximum current return rather than long term security *[15]* . The widespread network of plant breeders, the removal of sensitivity to latitude (i.e. daylength), and the manifestly greater yields of some genotypes have made the world population of several crops amazingly uniform. In the most striking case, most of the millions of acres of corn in America in 1970 had cytoplasm passed down from an ear of corn from Texas. Since the danger of genetic homogeneity has been demonstrated repeatedly as in wheat rust and oat and corn blight, contemporary agriculture knows that maximum current return from the single best variety is insecure. Nevertheless, in an inversion of Gresham's Law, the variety that currently returns most drives out others, making contemporary agriculture more currently productive but less secure.

Thus contemporary American agriculture has been shaped by choosing to save labor rather than fuel, to save man-hours rather than jobs, to save acres rather than chemicals, and to see current return rather than security. If we want another agriculture, we shall likely regress from our present goals as we progress toward others. We rarely eat our cake and have it, too.

Shadows Which Futurity Casts Upon the Present

Apprehension is in the mind and cannot be put in a Table. Nevertheless, agriculture has enjoyed and suffered the revolutionary changes that cause 'future shock', and shadowy anticipations which futurity casts upon the present are a significant ingredient of contemporary agriculture.

The deepest shadow on contemporary agriculture may be the one case by the melancholy memory that most farmers have fallen by the way during the past 40 years and by the apprehension that more will fall tomorrow. Although the halving of agricultural employment while the other employment has doubled is a mark of agricultural efficiency, it also means that farmers are a shrinking minority who may wonder which neighbor will pass tomorrow. The decline in farm acreage and its conversion to suburbia is so precipitous in some states that the general public is concerned, and in Connecticut, for example, a legislature with scarcely a farmer in it has reduced taxes to encourage the survival of farmers. Although agriculture abounds in opportunity, the shadow of declining numbers is a feature of contemporary agriculture along with its inventory of acres, tractors and so forth.

Another shadow cast by futurity is the emerging American interest in each other's land. When Europeans came to America they began dividing it up and assigning private ownership, right down to the water edge. This ownership was the right to "enjoy", doing anything one wished that was not illegal like murder or moonshining. During the past half century, however, this freedom has been abridged as we became more closely packed and realized that stinks, noises and even unpleasant sights from one man's enjoyment of his property could unfairly decrease another man's enjoyment of his property. The consequent abridgement of the owner's liberty is called zoning, and it has spread from town to town across the nation.

Environmental controls and impact statements are further manifestations of the neighbor's concern about the external effects of a man's enjoyment of his property. As if all this were not change enough, even more approaches as a quiet revolution in land use control. The impetus is the evident gobbling up of resources: in Connecticut, for example, three centuries of settlement by Europeans and a century of industrialization had put 10% of the land in urban uses, and then in a single decade this jumped to 16%. Several states are experimenting with land use planning and a National Land Use Policy Act is pending. "The ancien regime being overthrown is the federal system under which the entire pattern of land development has been controlled by thousands of individual local governments, each seeking to maximize its tax base and minimize its social problems, and caring less what happens to all the others" *[1]*. Thus the shadows cast by futurity include the possible cessation of suburban sprawl and reservation of cropland as well as the environmental restrictions that are already in view for farmers.

A different apprehension that I, at least, would add is whether in the future we shall eat relatively more beans or more beef. Although recent history clearly says "more beef", I see some flies on that facile extrapolation. Some of the flies come from the manure: the Council on Environmental Quality *[3]* predicts up to $3 billion in capital expenditures to control feedlot discharges. Other flies rise from the steadiness of the pounds of feed consumed by cattle per unit of milk or meat produced, a fact visible in Agricultural Statistics. This is quite different from the doubling of soybeans per acre in 30 years. These flies on the prediction of ever more steak on the broiler make me, at least, apprehensive that our present cattle troubles may be rehearsals for eating beans more directly than via cattle.

A safer prediction can be made about people: they will increase. A farmer looking at a chart of population sees good news and bad news: they're is no shortage of customers, but they're getting more crowded. Farmers perish when producing surpluses and suffering low prices in the short run. In the long run, however, there seems no question that the rising agricultural exports of 1972-3 are a shadow of the future. For example, Indians have been serious about family planning and about raising food production. Despite all this, the number of Indians increased by about 2/3 while food grain was doubled, and the overwhelming majority of Indians are still near starvation and subject to the vagaries of monsoons *[4]*. I, therefore, fear that the gloomy Paddock Brothers and Club of Rome rationally cast a shadow over contemporary agriculture: mobs of customers with little food in their bellies or money in their pockets.

Another portent for contemporary agriculture concerns the American position as lords of the creation. For a quarter century we have surely been the top nation, consuming a third of the world's beef and energy, and increasing our GNP more between 1970 and 1971 than the total GNP of all of Africa. We would, however, have that blindness of the proud before their downfall if we did not see signs of change on the horizon. The dollar is no longer unassailable, and an inventory of contemporary agriculture must include the probability that, as the world grows short of resources, Americans may no longer get the lion's share.

The final shadow of futurity that I will mention falls from the intersection of our environmental morality and our position as lords of creation. It is my impression that concern for conservation is higher among the affluent than among the needy. This impression is reinforced by the studies revealing the severe impact of environmental control upon the marginal, the rural and the small *[3]*. Thus the final shadow of the future that I would mention concerns the sturdiness of environmental morality should we grow short of fuel, food or money.

Concluding Optimism

Since no reader can have reached this point feeling that I play the part of Pollyanna, he will, I hope, find my rays of hope believable. They are not hard to bring forth in conclusion.

The first optimism about the continuity of agriculture and mankind derives from a skeptical view of forecasts. One could begin with the observation that the end of the world has been predicted frequently and the world has always survived, often preserving the prophets of doom themselves without prejudice. Another reason for skepticism rises from the nature of the forecasts. The Pollyannish sort, of course, gets its happy answers by an endless extrapolation of recent improvements in efficiency without much thought for the common sense that decreasing returns generally set in. A careful look at recent yields of wheat, soybeans, sugar cane or potatoes will show how yields became hard to raise after a while, and I shall not try to support forecasts that say we shall long extract nearly free benefits from agriculture as we have in the recent past. Because I have already suggested that the gloomy Paddock Brothers and Club of Rome cast an accurate shadow, I shall have to show considerable new skepticism to be optimistic in the presence of their inexorable lines of rising demand for cropland crossing the unyielding supply of land at a doomsday of 2000 to 2050 A.D. My optimism comes from my convictions that there is a slowing rate of progress towards doomsday. Men are neither robots nor lemmings who march blindly into the sea. When a resource becomes scarce, its price rises and its use declines. When an aesthetic value as wilderness, historic mansions or wetlands become scarce, a morality arises to protect them. When a danger to health appears or is suspected as aminotriazole in cranberries or diethyl stilbesterol in cattle, the hazard is removed despite costs. Thus doomsday will not soon arrive because man does change his course in response to signals, and his response makes gloomy forecasts mere signals and not the crack of doom.

Responses, which could be called evasive actions, are possible and my optimism is justifiable only if we have areas to maneuver in. We do, and they are the areas of 1) conservation by choice or change in style, 2) environmental controls and 3) research.

Conservation by choice means to me changes that we could make without any scientific break-through or discoveries of unknown mother lodes. These changes and conservations are, in a sense, ready for us to use if we will manage differently. In an examination of the efficiency of energy use Hirst and Mayers *[10]* point out obvious and large savings that could be made in transportation and space heating, which are the largest consumers of energy. Their suggestions concerning transport are made because there is a hundred-fold difference in the Btu/ton-mile between a pipeline and a plane and a five-fold difference in the Btu/passenger-mile between a bus and a plane. We consume 25% more energy to move freight and 22% more to move ourselves between cities than we would by a hypothetical scheme using more pipe and bus and less truck and plane. In other words, we have a considerable reserve in our energy supply available by changing the way we do things.

Another reserve was, of course, un-used cropland. In 1972 we had 63 million acres or about one acre in five in reserve. We have now plowed much of that reserve, but some is still unplowed.

The largest food reserve, however, is in our consumption of meat rather than plants. The amount of feed consumed by animals to produce a pound of meat can be expressed in the equivalent feeding value of corn *[17]*. This calculation shows 10 pounds of feed to produce a pound of beef cattle, 6 pounds for hogs and 2½ for broilers. There are qualifications on these ratios, preventing a flat statement that we could feed 2 to 10 times as many people by feeding plants to people directly rather than via animals. Among the qualifications are: we already eat a lot of plants; cattle can digest hay and we cannot; or a Midwestern acre will yield more corn for feed than wheat for bread. Nevertheless, so long as we eat meat, there is a reserve in our food supply that can be used by the unpleasant choice of less beef on the broiler and more beans in the pot.

Changes in style are closely related to conservation by choice. Style, however, seems to me a persuasion by our fellows rather than a choice consciously managed as providing more buses and fewer highways, raising the specifications for insulation, or withdrawing cropland from reserve.

The increase of the American population has changed as much as two-fold in a quarter century without a conscious governmental program and I am attributing this change to 'style'. Thus, a large population does have the ability to grow slowly or rapidly in response to signals from the environment, and this is a reason to be skeptical of the prophets of doom and a reason for optimism.

Another change in style that has an impact on agriculture is country vs. city living. During my short life I have seen people change from the style of moving to town to the style of moving to the country. When I was a boy people were drawn to the bright lights of the city, and now they want to live in the country despite irksome commuting. This change in style has consumed acres of farmland in building lots, highways and shopping centers. Clearly cities are going to have to become more livable and suburbs more expensive before the style changes back to city living, but a style of city living is possible as other times and countries testify. Construction of multifamily housing has increased more rapidly than single family housing recently (1965-1971). This change in style would conserve cropland and energy and is a reason for optimism.

Environmental controls, although an irritation to the manager who must incorporate them, should also be a cause for optimism. As we train more people to operate the controls, the cost should decline. The reservation of cropland is even a conceivable fruit of environmental awareness. As technological assessment is refined, we should have fewer environmental controls that merely bring on more environmental or resource problems. And we should eventually realize that wise controls are not costly to society as a whole but merely shift expenses once borne externally by by-standers to the internal accounts of the former polluter.

The concluding optimism I shall mention is research. Scientists are an optimistic race. Only an incurable optimist, the scientist, would continue testing wild ideas in the face of the incredible odds against all new things, and this incurable optimism is reinforced by a century of scientific success against these long odds. I believe that the unchanging efficiency of converting feed to meat in a cow will be a challenge to these optimists. I believe they will invent ways to using manure and the nutrients it holds far more conservatively than employing scarce fuel to incinerate and disperse the nutrients. At the same time the optimists may well learn how to conserve the trash and sewage of the cities through compost and irrigation. The elimination in 2 years of a major defoliator of Connecticut forests under the attack of a small wasp *[12]* and the opportunity for pest forecasts and consequently more precise aim by the controller make me believe that pest control, in the long run, will not require so many chemicals that it will be a major environmental issue. And the prompt control of the

Southern corn leaf blight is encouraging: even the sudden attack of an unheralded pathogen upon a major and genetically vulnerable crop can be contained so long as we have stocks of germ plasm, an agricultural research establishment tuned to the needs of the countryside, and a technologically adept agricultural industry.

Contemporary agriculture runs faster than the farming of a century ago, depending more upon outside supplies and supporting many more consumers. It is more susceptible to blights and more influenced by foreign famines. I cannot conceive that it will give way to a Buck Rogers industry consuming much more energy and resources and producing a hundred-fold as much food per acre. I can, however, conclude optimistically that mankind's intelligence will turn us aside as we near the Malthusian chasm and that future agriculture through invention and good sense will yield some more food per acre and thus sustain rather than sink this intelligent species.

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